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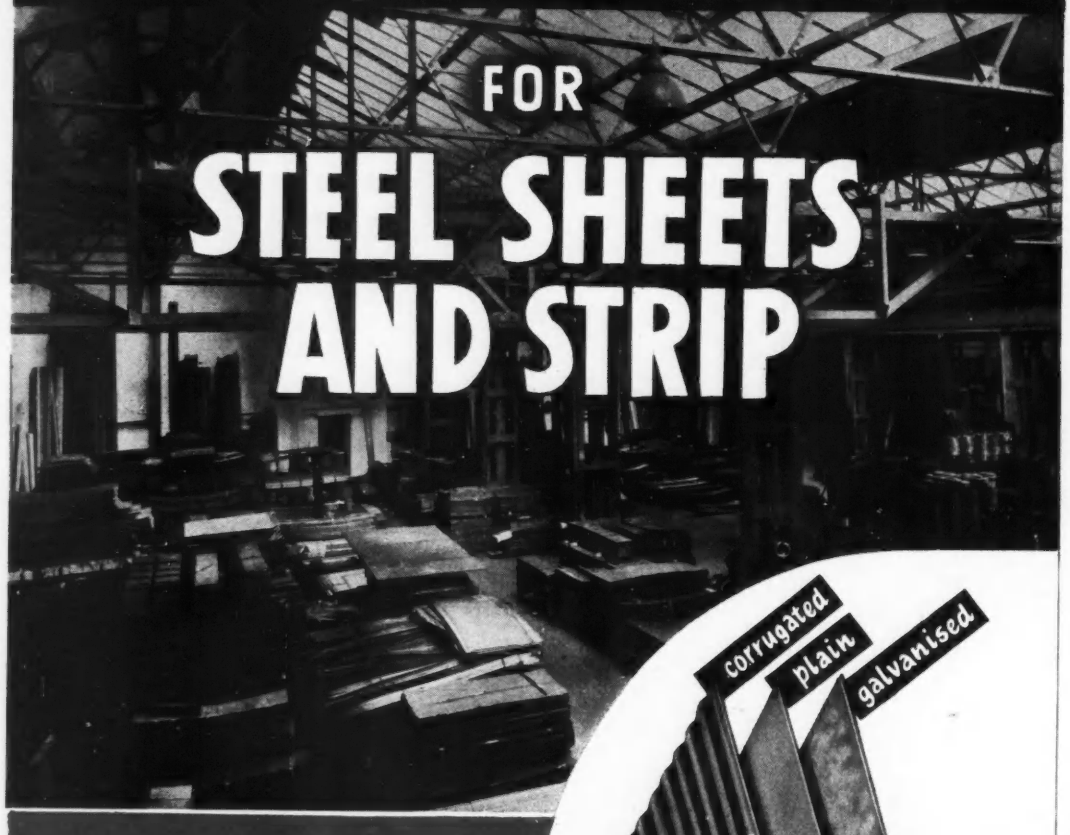

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## INDUSTRY AND EUROPEAN FREE TRADE

It is now about a year since the Government propounded a plan for setting up a European Free Trade Area (E.F.T.A.) around and including the Common Market which Western Germany, France, Italy, Belgium, Luxembourg, and the Netherlands were at that time proposing to create. The immediate reception given to the proposition by British industry was mixed. But to judge from a Federation of British Industries letter to the President of the Board of Trade issued in November, only a small minority of industrial associations were actually opposed even to the opening of negotiations. Since then the Rome Treaty has been signed, and in January, 1959, the first reductions in tariffs will occur amongst the six signatory nations of the Common Market. What does British industry now think of the Government's proposition ? Actually there is no more definite evidence upon the point now than there was before. But a qualified answer can still be offered to the question. In April the Federation of British Industries published a survey of European Trade with special reference to the kinds of safeguards that would be necessary within a Free Trade Area ; now, this week, it has published jointly with the Association of British Chambers of Commerce and the National Union of Manufacturers a Report on the European Free Trade Area. It is not the job of that Report to state whether industry actually favours E.F.T.A. or not. Instead, it examines the implications of E.F.T.A. as affecting British industry and studies in some detail what kind of terms should be embodied in any treaty that may be negotiated. The fact that industry has been to such great trouble to study in detail the implications indicates at least a deep interest in the proposals. No more could be expected at this stage ; because, until the terms of an actual treaty have been drawn up, industries cannot be expected to form firm opinions about the advantages or the reverse of joining E.F.T.A. Undoubtedly too high a price could be paid for joining it, and it is by no means certain that all other countries will accept as easily as ours the rigid exclusion from the free trade provisions of food, drink and tobacco. Were the exclusion to be less than rigid, Imperial Preferences might be seriously affected.

The Report, it will have been noticed, is concerned with the kind of treaty which would satisfy industry of the feasibility of joining a Free Trade Area without damage to Commonwealth trade. It can, possibly, be deduced that if the treaty conformed closely with the ideas expressed, British industry as a whole (but not certain sections of it) would finally favour the setting up of the Area. What kind of treaty has industry in mind ? The point has been grasped in the document that if there is to be free trade there can be very few industries excepted from it and specially protected from European competition. The document is therefore firstly concerned to lay down three partly interrelated principles : that entry into E.F.T.A. should not be incompatible with the maintenance of the existing structure of Imperial Preference, that this country should not surrender its right to maintain its own tariff policy *vis-a-vis* the outside world ; and that food, feeding stuffs, drink and tobacco should not be included in the E.F.T.A. arrangements. Thereafter it is concerned, not with methods of " protecting " British industry from the competition of other European countries, but with ensuring that competition between the various countries should be equitable and fair ; that is that the progressive reduction and abolition of tariffs, duties, import quotas, &c., within the E.F.T.A. should be so timed that the dismantling operation broadly coincides with that of the Common Market ; that the rules should forbid Governments to offer export subsidies or similar incentives, open or concealed ; and that discrimination in transport charges should come to an end. It is pointed out that definitions of origins of goods may have to be worked out industry by industry if inequities are to be avoided. The question of dumping is discussed; and for many matters it is proposed that there should be set up a complaints and appeals procedure. It is also suggested that taxation policies, wage costs, and social charges shall not be covered by E.F.T.A. and that each country shall be free to adopt its own policies about restrictive practices. On certain other matters industry remains doubtful about the practicability of incorporating anything in the proposed E.F.T.A. treaty. Access to raw materials

constitutes one of these matters and the purchasing policy, national or international, of nationalised industries constitutes another. On still other matters, such as invisible trade and services, and patents and trade marks, it is clear from the Report that studies have not proceeded far enough for firm conclusions to be drawn. Rather than set up supranational organisations to regulate and control the E.F.T.A., industry would prefer it to be established within the O.E.E.C. Amongst matters not discussed are movements of capital and the mobility of labour across national boundaries. There is a brief reference to standards.

There remains to be noticed an important Appendix to the Report. It relates to hard-hit industries. Again, however, the approach seems to us eminently sensible. It is recognised that the benefits to be expected from the setting up of a European free trade area are likely to arise because the production of certain goods will become concentrated in certain areas favoured by natural or other circumstances. Certain British industries might well benefit in this way; but certain others, through no fault of their own, might be hard hit. It is suggested that, within E.F.T.A. arrangements Governments should be permitted to give temporary assistance to such industries or firms (or to whole industrial areas) to enable them to establish themselves in some new field of manufacture. In addition, no sovereign Government under present world conditions could be expected to allow certain key "security" industries to be ruined by international competition. Maybe in the future confidence will grow amongst the European nations, drawn together by the Rome Treaty and by the existence of E.F.T.A., to such an extent that such safeguarding of key industries will become unnecessary. But that time is not yet. The setting up of the Common Market and the Free Trade Area may well prove to be steps towards the creation of some form of federated Europe, a thing a few men in this country (but possibly more abroad) wish to see come about. But for our part we believe in evolution. If and when the Common Market and the Free Trade Area are operating smoothly the question of developing integration further will arise naturally and facts will be available upon which to base conclusions about its advisability. The cautious approach of British industry to the E.F.T.A., proposals seems to us therefore wise and we hope the peoples on the European Continent will not misunderstand it. They would be wrong to suppose that it expresses a timid or ungracious half-heartedness. Hard-headed British industrialists want to know precisely how they stand before they express unqualified approval of or opposition to E.F.T.A.

## PROBLEMS OF RAILWAY MODERNISATION

The vast project of railway modernisation in Great Britain presents, to the very diverse branches of engineering concerned, a challenge and an opportunity that is not likely to occur again. With this opportunity, and with this challenge have come problems that are little realised, and still less understood outside the ranks of railway engineers, and it was to some of these problems, particularly affecting the men concerned with motive power and rolling stock, that Mr. E. S. Cox referred on Wednesday, September 25, 1957, in his presidential address to the Institution of Locomotive Engineers. One can appreciate how, to one of his keen sense of the historical perspective, the present situation appears, and we can share his evident pride that the task of modernisation on so colossal a scale has fallen to this generation. For, make no mistake about it, the task is colossal. As yet the plan, outlined some three years ago, has scarcely begun to get into its stride, and it is in the "Approach to Modernisation," as Mr. Cox titled his address, rather than with the ultimate execution of the scheme that the greatest problems for engineers arise. In the manufacture of electrical equipment, of diesel locomotives, of lightweight rolling stock, and of modern signalling, a wealth of experience exists among British firms. But it is not easy to decide what to make, and the most interesting part of Mr. Cox's address was that in which he discussed some of the factors to be considered, before decisions could be made on four major issues—the selection of motive power types; the relation of power to train weight; the inter-relation of the motive power, as a vehicle, to the track, and what he aptly described as "the endless contest of standardisation with diversification."

None of these problems is in itself new. Either singly or together they have been appreciated and faced by railway administrations in every part of the world. But never, one can safely assert, has a railway system of the size, complexity and diversity of our own been given the task of carrying through so great a changeover in so very short a time. This is no time to question the administrative wisdom of setting so hot a pace; railway engineers, so long denied the opportunity of displaying their skill on a big scale in modern conditions, will revel in the task. The risks are, nevertheless, very real. In the ordinary way, where locomotives are concerned, lengthy tests with various prototypes would have been carried out; experience would have been gradually built up, and a code of practice formulated to suit the individual needs of different routes. With the B.T.C. Plan, however, time does not permit of the old characteristic methods of British railways. The varied practice and experience of Continental and American railways has had to be studied at top speed, and decisions made for the prototype batches of diesels that are based for the most part on the experience of others, in widely differing running conditions. Mr. Cox told how, in response to the Commission's first inquiry for main line diesels, in 1955, no fewer than 200 varieties were offered by British, Continental and American firms, and from these a choice had to be made of the more promising for a first trial. It is true that the locomotives at present on order represent no more than a pilot scheme; but it is a pilot scheme on a very large scale.

One of the difficulties that has faced the engineers of the British Transport Commission, to which Mr. Cox referred in several parts of his address, is the amount that has been written in various forms of technical literature extolling this or that feature of diesel locomotives, transmission systems, and so on. He himself feels, for example, that the relative merits of electric and hydraulic transmission have yet to be established. There is controversy over bogie design, and the correctness of the first decisions upon the power of locomotives in relation to weight hauled has yet to be tested and proved in actual traffic. From the lucid way in which Mr. Cox presented, one after another, the problems that he and his colleagues are facing, it is evident that a great deal of what he called "integrated thinking" is in progress; but a remark he addressed particularly to the problems of vehicle riding, in relation to permanent way design, could well be applied to the plan as it affects rolling stock in general. "It is unlikely that finality can ever be reached because of the interplay of contradictory requirements and the increasing demand for high speed and more amenity." A rather disturbing accompaniment to the gradual evolution of the plan (not, however, mentioned by Mr. Cox) is the frequency of change in organisation in the operating and engineering departments of the various Regions of British Railways. It is no doubt felt that the existing arrangements are not suitable for the new era that is now gradually taking shape, but the upshot of further change is that not for the first, nor even the second time since nationalisation many key men in what might be termed middle status just do not know where they stand. Mr. Cox, in his address, tells how in the past the lack of exact knowledge and scientific understanding have impeded progress on engineering matters; to-day, when the mists of obscurity are being cleared away on so many technical matters, it is to be fervently hoped that the psychological effects of the change will not be overlooked, particularly as they concern engineers not yet attaining to middle age on whom the burden of "front line" duty will fall as the plan proceeds.

# A Seven Day Journal

### Christmas Island Air Base

ENGINEERING works forming part of the national defence programme can be referred to only rarely in these columns, because of the secrecy which must inevitably surround them. It is therefore of particular interest to record some details of the civil engineering work carried out on Christmas Island prior to the tests of the British hydrogen bomb in May and June of this year. The construction of the runway on Christmas Island was described in a paper presented before the Institution of Highway Engineers recently by Major V. J. M. Smith and Mr. R. Airey.

Instructions to plan the tests, based on Christmas Island, were given in November, 1955, and a target date for completion of all engineering works was set at April 1, 1957. A temporary air base for over forty aircraft had to be provided, and its design and construction is described in detail in the paper. It was, however, also necessary to accommodate a task force of over 2500 men, with port, power, water, fuel and scientific installations. Constructional forces, plant and stores were landed on the island by about mid-September, and the principal task of runway construction had started by then. Reconstruction of the existing 7000ft runway for use by "Valiant" bombers fitted with delicate instruments and, therefore, demanding a high standard of surface finish, was completed by March.

The main civil engineering problem which was presented was the use of coral as the material for the pavement bases, and the aggregates for concrete and bituminous construction. In the event, successful results were achieved. A 210ft length at each end of the runway was concreted for the full width of 180ft, to give take-off and turning aprons; bituminous construction was used for the central section. One subsidiary airstrip 5000ft long was also rehabilitated, standing or parking aprons for thirty-eight aircraft were built, and taxiways reconstructed. Construction was considered to be temporary, a six-month life being specified.

### National Smoke Abatement Society

THE annual conference of the National Smoke Abatement Society is being held at Hastings this week. In his presidential address on Wednesday, Dr. R. Lessing emphasised that the solution of the domestic smoke problem demanded the replacement of house coal in open grates by smokeless fuel, or the installation of modern appliances. In industry, he added, the 40,000 hand-fired boiler furnaces must be fitted with mechanical stokers which were suitably instrumented and competently operated.

As to the grit and dust discharged from the country's chimneys, Dr. Lessing contended that a large, if not a major, portion was derived from the "natural" dust in coal. If the National Coal Board could be persuaded to incorporate de-dusters in its coal preparation scheme, he said, the problem of dust arresting on thousands of boiler plants would be eased and emission diminished. By the pneumatic de-dusting of coal prior to washing, the slurry nuisance would be abated whilst the product from de-dusters would find a satisfactory outlet in pulverised fuel plants. Dr. Lessing referred also to the potential dust nuisance from pulverised fuel firing. He suggested that to reduce the amount of dust and incidentally lighten the load of the precipitators, a substantial portion of the high ash part of the "untreated smalls" used by power stations and other large works should be removed at the colliery.

### Road Scheme in the City of London

WORK has started on the construction of a new road between Aldersgate Street and Moorgate, forming the first section of the projected Route 11 in the City of London. It will take about two years to complete.

The Ministry of Transport and Civil Aviation states that this section is part of "a long-term plan to relieve the more congested areas of the City by providing a new west-east route from an enlarged Ludgate Circus to Aldgate." For traffic between Newgate Street and Moorgate it will form a by-pass to the Bank intersection. The new road will be 600 yards long and will have two three-lane carriageways and two 12ft footways.

The City Corporation is building beneath the road an underground car park for 250 cars, extending over the whole width of the carriageways for a length of about 400 yards. This scheme takes advantage of the existing levels, the road being carried on a continuous viaduct of reinforced concrete. The cost of the whole scheme amounts to £1,320,000, towards which the Minister of Transport and Civil Aviation has made a grant of £726,075 to the Corporation of the City of London. The cost of the car park is being borne entirely by the Corporation. The work will be carried out by contract under the direction of the City engineer, Mr. F. J. Forty, M.I.C.E.

## The Engineer
## 100 Years Ago

(OCTOBER 2, 1857)

"NEW SCREW PROPELLERS"

"A lieutenant in the French navy, M. Vergne, has invented a new steam screw propeller, which he calls the fluted screw. The improvement is founded on a very nice observation of the directions taken by the particles of the water displaced and repelled by the screw. A commission was appointed to compare the workings of the old and new screws. The persons composing it embarked at Toulon on board the Vigilant, an iron steam despatch boat of 60-horse power, fitted with the ordinary screw. Four trips were made along a measured distance; then the screw was replaced by that of M. Vergne's invention, and four other trips were made along the same line. The result showed a gain of 17 per cent in speed with the next screw, and the almost complete suppression of that disagreeable vibration usual in screw steamers, and which in small vessels renders it necessary to make the hinder part of the ship heavier and more costly than it otherwise need be. The question has been raised whether the same advantages would be obtained in large vessels. Some scientific persons believe that they would, even in a greater degree, and give reasons for their belief. This question will soon be set at rest, for the Emperor has ordered the experiment to be renewed, this time on a ship of the line. As far as the invention has yet been tested, it seems well deserving the attention of our English naval engineers."

"EXPORT OF COAL"

"The total exports of coal from the United Kingdom during August amounted to 613,834 tons, against 625,389 tons in August, 1856."

### Opening of Marine Engineers' Memorial Building

WEDNESDAY, September 25, marked an important day in the history of the Institute of Marine Engineers, in that the building, which has been designed as a war memorial and as the new headquarters of the Institute, was opened by Admiral of the Fleet, The Earl Mountbatten of Burma. The building, the foundation stone of which was laid on November 16, 1955, by H.R.H. the Duke of Edinburgh, is at 76, Mark Lane, London. It covers a ground area of about 12,500 square feet and incorporates a tower measuring 80ft long by 50ft wide and 162·5ft high. There are two basement levels, ground, and seven floors, with the tower rising to fourteen storeys. Within that part of the building occupied by the Institute the principal apartment is the imposing lecture hall, which has seating accommodation, including the gallery, for about 350 people, with windows on one side giving access to a roof garden.

Before the official opening Mr. A. J. Silley, a past-president, briefly reviewed the history of the Institute, which has a steady membership now numbering 11,500. The opening ceremony was completed by Earl Mountbatten unveiling the memorial book, in which are recorded the names of the marine engineers, of both navies, who lost their lives in the war.

### Lord Bennett of Edgbaston

LORD BENNETT OF EDGBASTON, whose death occurred suddenly last Friday, September 27, had an eminent place in the engineering industry, especially in the Midlands. For many years he was chairman and joint managing director of Joseph Lucas, Ltd. More recently, following Mr. Neville Chamberlain's death in 1940, Lord Bennett (then Mr. Peter Bennett) was Member of Parliament for the Edgbaston division, and from 1951 to 1952 served as Parliamentary Secretary to the Ministry of Labour and National Service. Lord Bennett, who was seventy-seven, was born in Kent; he moved to Birmingham while still a boy, spent a short time after leaving school in the service of the Austin Company, and subsequently joined the Lucas organisation. His contribution to the development of that organisation was a notable one. There were, in addition, many Government and other public services which Lord Bennett readily rendered, particularly during and immediately after the second world war. He was a past-president of the Federation of British Industries and of the Birmingham Chamber of Commerce. Lord Bennett was raised to the peerage in 1953, having been created a knight in 1941.

### Hinkley Point Nuclear Power Station

IN the summary at the head of the article on the Hinkley Point Nuclear Power Station which appeared on page 415 of our issue of September 20, there was a very misleading misprint. The net guaranteed electrical output of the two reactors to be installed at this station was printed as 5MW. The true figure is 500MW. Fortunately the correct figure was printed a very few lines down in the body of the article itself. But so much attention is given to summaries that some readers and possibly some of those who prepare abstracts for publication in various journals may have been misled. Since a totally inaccurate conception of the importance of the power station was conveyed, we hasten to publish the correct figure. Hinkley Point Nuclear Power Station will generate 500MW, not 5MW.

# Locomotive Development in 1907

By E. C. POULTNEY, O.B.E.

LOOKING back fifty years to 1907, attention is mainly focused on important innovations in locomotive design, initiated by G. J. Churchward at Swindon, which included the completion of his famous engine No. 4001, "Dog Star," the first of the well-known four-cylinder six-coupled 4–6–0 express passenger locomotives which, as subsequent events have shown, were destined to have a profound influence, not only on later Swindon practice, but also, in the course of time, elsewhere. Other developments at Swindon included the introduction of an enlarged tank engine design of the 2–6–2 type and further experimental applications of flue tube superheaters, this time to four-cylinder engines of the design just mentioned. Further locomotives turned out included a series of the standard two-cylinder 4–6–0 for express passenger services. These were a continuation of the 1903 design cylinder design by D. Drummond for passenger service on the London and South Western. This was similar to the lot built previously, in 1906, but slightly modified. Turning to Doncaster, H. A. Ivatt built another compound, No. 1421, rather like his previous engine No. 292 of 1905. The new engine, like the former example, was of the 4–4–2 type for passenger services on the Great Northern line.

### The Great Western Engines

Considering these several developments in chronological order, Churchward's engines (Figs. 1 and 2) claim prior notice and, as is often the case, it will be helpful if reference is made to the pages of THE ENGINEER, which have so frequently chronicled successive developments that have taken place in locomotive practice. For instance, if we turn to the issue of May 12, 1907, an article

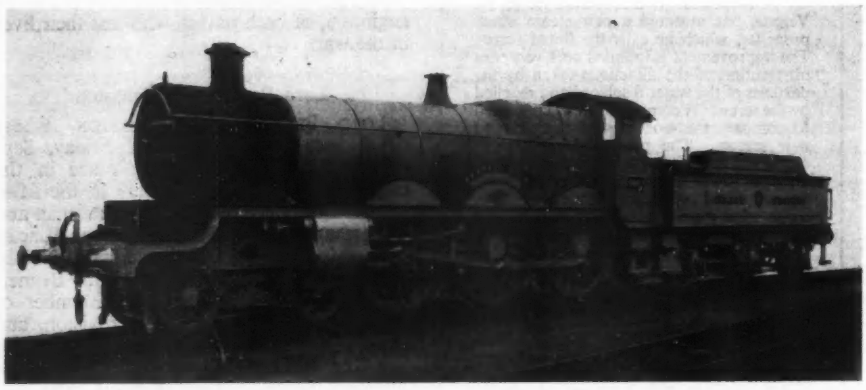

Fig. 1—Churchward's engine "Evening Star" for the Great Western Railway

and like "Lady Superior" of 1906, but were not superheater fitted. For the Midland, R. M. Deeley brought out at Derby a large 4–4–0 engine for main line express passenger traffic, embracing interesting features, and for the Great Central J. G. Robinson designed and Beyer, Peacock and Co., Ltd., built some large three-cylinder, eight-coupled engines for heavy shunting duties, more especially at the important Wath classification yards, where heavy coal trains were made up for transit over all parts of the system. A further locomotive claiming notice is another four- will be found from the pen of a one time well-known writer, Charles Rous-Marten, whose subject on this occasion was Churchward's new engine No. 4001, and who gave his contribution what would now seem the prophetic title, "New Type of Great Western Engine : An Evolution."

Certainly the impact that Churchward's engine No. 4001, "Dog Star," had on subsequent locomotive designs for heavy and fast passenger services was considerable, setting, as it undoubtedly did, a high standard of performance in relation to that normally prevailing at the period. Basically, the new engine was in fact the four-cylinder engine, No. 40, "North Star," fitted with a third pair of coupled wheels in place of the trailing carrying wheels of the original engine, which had the 4–4–2 wheel arrangement. The cylinders were arranged in the same manner and had piston valves as before, but the valve gear was altered, for, instead of Churchward's special adaptation of Walschaerts gear used for No. 40, as described in the last of these articles, a conventional form of Walschaerts valve gear was designed in which the oscillation of the expansion links was derived from eccentrics mounted on the leading coupled axle between the crank webs. As in the case of the first four-cylinder engine, the valves for the outside pair of cylinders were operated by the adjacent inside valve gears by horizontal rocking levers. Like the engine "North Star," piston valves 8in diameter were fitted for the 14½in by 26in cylinders.

Generally the new engines were similar in detail design to others with the same wheel arrangement ; thus, the spring suspension to the coupled axles included compensating beams common in American practice, and the standard type of four-wheeled bogie was of the swinglike pattern with frames of the bar type ; this bogie was, however, only fitted to the first ten engines, Nos. 4001–10, those following being given a new design in which the weight carried by the bogie was transferred from the centre to outside bearing brackets fitted with hemispherical sliding numbers resting in similar cupped slides on the bogie frames. In the case of the new bogie, lateral motion was controlled by helical check springs. An excellent set of drawings of the later "Star" class engines will be found in THE ENGINEER of December 16, 1910. The cross sectional drawing shows this bogie clearly, which was very similar to those fitted to the French compounds then running on the Great Western.

With the completion of the engine "Dog Star" there were then four different locomotive classes for heavy express passenger main line services on the Great Western. These different classes comprised two-cylinder four-coupled and six-coupled 4–4–2 and 4–6–0 engines and four-cylinder engines also having four-coupled and six-coupled wheels of the same kind as for the earlier two-cylinder locomotives.

All these engines had the same No. 1 standard boiler, having the same working steam pressure and also driving wheels of one standard diameter. As a point of interest in view of the degree of standardisation attained except in the cylinder arrangements, the following details of the relative weights




| | T. - C. | T. - C. | T. - C. | T. - C. | T. - C. | T. - C. | T. - C. |
|---|---|---|---|---|---|---|---|
| Weights Full | 20 - 4 | 18 - 12 | 18 - 12 | 18 - 4 | 13 - 10 | 13 - 4 | 13 - 6 |
| Weights Empty | 18 - 15 | 17 - 5 | 17 - 5 | 16 - 18 | 6 - 5 | 6 - 0 | 6 - 0 |

Fig. 2—Weight diagram of the engine "Evening Star"

of these engines and the effect of changes in the weight available for adhesion will be of interest:—

*Great Western Locomotive Details*

| | |
|---|---|
| Two-cylinder, 4-4-2 : | |
| Weight : | |
| Engine, tons... ... ... ... ... ... | 70·5 |
| Adhesive, tons ... ... ... ... ... | 39·0 |
| Tractive force, pounds ... ... ... ... | 23,090 |
| Adhesive factor ... ... ... ... | 3·78 |
| Two-cylinder, 4-6-0 : | |
| Weight : | |
| Engine, tons... ... ... ... ... ... | 70·2 |
| Adhesive, tons ... ... ... ... ... | 54·2 |
| Tractive force, pounds ... ... ... ... | 23,090 |
| Adhesive factor ... ... ... ... | 3·26 |
| Four-cylinder, 4-4-2 : | |
| Weight : | |
| Engine, tons... ... ... ... ... ... | 74·5 |
| Adhesive, tons ... ... ... ... ... | 39·6 |
| Tractive force, pounds ... ... ... ... | 25,200 |
| Adhesive factor ... ... ... ... | 3·52 |
| Four-cylinder, 4-6-0 : | |
| Weight : | |
| Engine, tons... ... ... ... ... ... | 75·6 |
| Adhesive, tons ... ... ... ... ... | 55·4 |
| Tractive force, pounds ... ... ... ... | 25,200 |
| Adhesive factor ... ... ... ... | 4·93 |

It will be observed that the two-cylinder 4-4-2 engines and the one with four cylinders of the same type were somewhat light on the coupled wheels in relation to their respective tractive efforts, though both appear to have done excellent work ; in fact, some time elapsed before it was finally decided to adopt the six-coupled type as standard when all the 4-4-2 engines, including No. 40, the only four-cylinder engine with this wheel arrangement, were converted to the 4-6-0 type, No. 40 being so altered in 1909. From the particulars given of these engines it will have been noticed that the tractive force of the four-cylinder engines is rather greater than is the case with those having two cylinders, so that for equal running conditions the demand on the boilers of the four-cylinder locomotives would be somewhat increased and a further difference which should be remembered is in the valve gears fitted, for, while all the two-cylinder engines had Stephenson's valve gear, hitherto standard at Swindon, the new engine " Dog Star " had, as already mentioned, the Walschaerts gear, the first application so far as Great Western practice is concerned. This difference between these two classes, otherwise the same except in the number of cylinders, is of interest in view of the fact that Stephenson's valve gear normally produces more power at given rates of cut-off compared with the Walschaerts gear ; therefore this difference between these engines must not be overlooked. The actual difference in this respect between these two valve gears as indicated by specific tests on a locomotive testing plant has been discussed previously by the writer, THE ENGINEER, December 11, 1953.*

Turning to the performance of these two-cylinder and four-cylinder engines, the following particulars may be of some interest. The information concerning the two-cylinder locomotives is taken from a graph published in THE ENGINEER, March 23, 1906, giving "Albion," No. 171, from Paddington to Bristol. This diagram shows the powers developed at the tender drawbar, the speed attained, m.p.h., and the cut-offs used throughout the journey. Particulars of the running of an engine of the " Star " class, No. 4013, " Knight of St. Patrick," over the same road, but in the opposite direction, in the form of part of a pull-speed record, were given by K. J. Cook, Institution of Locomotive Engineers, 1950, and the following data deduced from the foregoing information appertains to the performance of these two engines at the same point on the road near Taplow, 22 miles from Paddington.

Both engines used saturated steam at the standard working pressure of 225 lb per square inch.

* See letter from H. Holcroft, THE ENGINEER, January 24, 1947.

*Engine No.* 171, " *Albion* "

| | |
|---|---|
| Cylinders, two ... ... ... ... ... ... ... ... | 18in × 30in, 10in valves |
| Gradient ... ... ... ... ... ... ... ... ... | 1 in 1320 up |
| Speed ... ... ... ... ... ... ... ... ... | 62 m.p.h. |
| Revolutions per minute ... ... ... ... ... ... | 259 |
| Piston speed, feet per minute ... ... ... ... ... | 1295 |
| Cut-off, per cent ... ... ... ... ... ... | 18 |
| Drawbar horsepower ... ... ... ... ... | 820 |
| Drawbar pull, pounds ... ... ... ... ... | 4963 |
| Engine constant, tractive force per pound of mean effective pressure ... ... ... ... ... ... | 121 |
| Mean effective pressure referred to drawbar tractive force, pounds ... ... ... ... ... ... | 41·0 |

*Engine No.* 4013, " *Knight of St. Patrick* "

| | |
|---|---|
| Cylinders, four ... ... ... ... ... ... ... ... | 14½in × 26in, 8in valves |
| Gradient ... ... ... ... ... ... ... ... ... | 1 in 1320 down |
| Speed ... ... ... ... ... ... ... ... ... | 69 m.p.h. |
| Revolutions per minute ... ... ... ... ... ... | 288 |
| Piston speed, feet per minute ... ... ... ... ... | 1245 |
| Cut-off, per cent ... ... ... ... ... ... | 20 |
| Drawbar horsepower ... ... ... ... ... | 915 |
| Drawbar pull, pounds ... ... ... ... ... | 4928 |
| Engine constant, tractive force per pound of mean effective pressure ... ... ... ... ... ... | 131 |
| Mean effective pressure referred to drawbar tractive force, pounds ... ... ... ... ... ... | 37·7 |

The foregoing computations, though details of the running of the 4-6-0 engine are admittedly not exactly conclusive, are certainly indicative as showing the increased cylinder horsepower attainable with Stephenson's valve gear. In this particular case " Albion " with this gear seems to have developed a higher mean effective pressure in cylinders at 18 per cent cut-off than " Knight of St. Patrick " at 20 per cent cut-off when the piston speeds were practically equal.

Actual tests carried out with the engine " Albion " gave the following impressive results :—

| Speed, m.p.h. | Tractive effort, tons | Drawbar h.p. |
|---|---|---|
| 30 ... ... ... ... | 6·3 ... ... ... ... | 1120 |
| 45 ... ... ... ... | 4·5 ... ... ... ... | 1280 |
| 60 ... ... ... ... | 3·2 ... ... ... ... | 1144 |
| 70 ... ... ... ... | 2·5 ... ... ... ... | 1045 |
| 79 ... ... ... ... | 1·4 ... ... ... ... | 665 |

For this information the writer is indebted to his friend, Harold Holcroft.

The principal dimensions of the original " Star " class engines are as under :—

*Great Western Four-Cylinder Express Locomotives, " Star " Class*

| | |
|---|---|
| Cylinders : | |
| Diameter and stroke, inches ... ... | 14½ × 26 |
| Driving wheels, diameter, inches ... ... | 80½ |
| Heating surfaces : | |
| Tubes, square feet... ... ... ... ... | 1988·65 |
| Firebox, square feet ... ... ... ... | 154·26 |
| Total, square feet ... ... ... ... ... | 2142·91 |
| Grate area, square feet ... ... ... ... | 27·07 |
| Engine weight : | |
| On drivers, tons ... ... ... ... ... | 55·4 |
| Total, tons ... ... ... ... ... | 75·6 |
| Engine and tender, tons ... ... ... ... | 115·6 |
| Rated tractive force, pounds ... ... ... | 25,200 |

## 2-6-2 TANK ENGINES

The new six-coupled 2-6-2 tank engines (Fig. 3) were built for heavy suburban passenger services in 1907, and were an enlargement of some of the same type originally designed by Churchward in 1903. The new engines had larger boilers, the standard No. 4, as used for the " City " and " County " 4-4-0 express passenger classes, and carried a higher working steam pressure of 200 lb, as against 195 lb per square inch for the 1903 engines. The standard cylinders as fitted to the original engines were retained, but had a diameter of 18½in instead of 18in. As the diameter of the coupled engines remained as before, namely 68in, the increase in the cylinder dimensions, together with the higher steam pressure, had the effect of raising the maximum tractive force from 23,600 lb to 25,670 lb. In common with all Swindon-built two-cylinder engines, Stephenson's valve gear of a standard pattern was actuating 10in piston valves. Other features characteristic of Churchward engines included the fitting of equalising beams in the spring suspension. In this case the leading pony truck was equalised with the spring gear for the leading coupled axle, an excellent arrangement, and the radial axle under the coal bunker was in like manner equalised with the springs for the trailing coupled axle.

Eventually forty of these engines were built and all in the course of time were equipped with superheaters.

The general dimensions of the class as built are as follow :—

*Great Western 2-6-2 Tank Engines*

| | |
|---|---|
| Cylinders : | |
| Diameter and stroke, inches... ... ... | 18½ × 30 |
| Driving wheels, diameter, inches ... ... | 68 |
| Heating surfaces : | |
| Tubes, square feet... ... ... ... ... | 1689·82 |
| Firebox, square feet ... ... ... ... | 128·3 |
| Total, square feet ... ... ... ... ... | 1818·12 |
| Grate area, square feet ... ... ... ... | 20·56 |
| Steam pressure, pounds per square inch... | 200 |
| Engine weight : | |
| On drivers, tons ... ... ... ... ... | 56·0 |
| Total, tons ... ... ... ... ... ... | 78·3 |
| Tractive force, pounds ... ... ... ... | 25,670 |
| Tank capacity, gallons ... ... ... ... | 2000 |
| Bunker capacity, tons ... ... ... ... | 2·75 |

## FURTHER SUPERHEATER APPLICATIONS

The further applications of flue tube superheaters undertaken at Swindon involved fitting two of the " Star " class engines, Nos. 4010 and 4011, the former with a Cole superheater and the latter with one of a Swindon design. The Cole arrangement is due to F. J. Cole, at that time the chief consulting engineer, American Locomotive Company. This superheater consisted of three rows of six units having an internal flow with an external return. The outward flow tubes passed through a gland in the partition dividing the saturated and superheated steam spaces of the header, the outer return tube being expanded in the outer wall of the superheated steam space. The Swindon design also had elements comprising inner and outer tubes similar to the Cole arrangement, and, like it, was made up of three rows of six elements. As was the case with the Schmidt superheater fitted to the engine " Lady Superior " in 1906, dampers were fitted, automatically controlled by a small steam cylinder and connecting gear. The dampers were shut when the regulator was

**Fig. 3—Passenger tank 2-6-2 engine, " 3150 " class, Great Western Railway**

closed, so preventing the hot gases from flowing through the flue tubes containing the superheating elements.

Particulars of the heating surfaces of these superheater boilers are given in the accompanying tabular statement.

### Deeley's Midland Engines

The last of the numerous examples of simple expansion 4–4–0 passenger engines for the old Midland Railway, Deeley's "990 class" of 1907 (Fig. 4) marked a notable

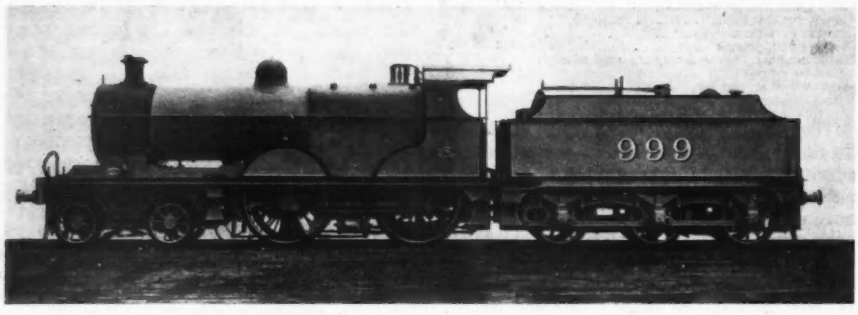


**Fig. 4—Midland Railway 4–4–0 Express Locomotive, "990" class—R. M. Deeley**

increase in power compared with those previously designed at Derby since the inception of the type by S. W. Johnson as long ago as 1876. For these, his first passenger engines for the Midland, Johnson used 6ft 6in drivers, though later preferring larger wheels, 7ft diameter and latterly 6ft 9in. Deeley, on the other hand, it is interesting to note, practically reverted to Johnson's 1876 design by adopting a diameter of 6ft 6½in for his new engines.

Deeley's earlier passenger engines of the 4–4–0 two-cylinder type, introduced in 1905, had, like Johnson's later designs, boilers of the Belpaire pattern, and the "990 class" were given boilers of the same type but of larger size, being duplicates of those provided by Deeley for his three-cylinder compound engines, and carried the same working pressure of 220 lb per square inch.† The heating surfaces totalled 1572 square feet and the grate area of 28·5 square feet was then the largest in the country for engines of the 4–4–0 type. The cylinders, inside, were 19in diameter with a piston stroke of 26in and had, like Johnson's later engines, piston valves of W. M. Smith's pattern; they were 8¾in diameter and placed above the cylinders instead of being arranged below and directly operated by Stephenson's valve gear, as had previously been the standard at Derby.

Deeley's cylinder design also presented a change compared with former Midland practice, a notable feature being the short straight ports between the valve bushings and the cylinders, for which purpose the valve heads were widely spaced, simulating in this respect Churchward's designs; contrary to the Swindon engines, Deeley used "outside" admission valves with the exhaust taking place between the valve heads, an arrangement which, while providing a free and direct exhaust, was not so good for the admission steam, due to the relatively small steam volume in the valve chambers, which is obviously greatly improved when "inside" admission is used, as is now universally the case.

The most striking feature of these engines was the valve gear, designed and patented by Deeley some years before, being first fitted to these new locomotives. Actually, the arrangement was in certain respects like the ordinary Walschaerts gear, inasmuch as the lap and lead lever for each valve was actuated by the corresponding piston-rod crosshead. The oscillation of the expansion link, which in the case of the Walschaerts gear is obtained by an eccentric or return crank according to whether the cylinders are "inside" or "outside," is in the case of the Deeley gear obtained from the crosshead on the other side; that is to say, the link for the right-hand set of valve gear was actuated by the left-hand piston-rod crosshead and vice versa. The left-hand expansion link was placed in front of the left-hand link and the two radius rods between the die blocks working in the expansion links and the lap and lead lever connection with the valve spindles was actuated for reversal and alteration of cut-off by one reversing shaft fitted with a two-armed lever, one end of which connected by means of a rod to one radius rod and the other end with the other radius rod, so that, when one die block was at the top of the expansion link, the other would be at the bottom of the other link.

Fundamentally, this gear was similar to Churchward's gear fitted to engine No. 40, "North Star," which, in view of Deeley's patent, was duly noted by the authorities at Derby when the Swindon engine was completed. A further feature of these locomotives worth notice is the use of a four-wheeled leading bogie having the swing link type of lateral control, new to the Midland, because Johnson had always favoured the more usual Adams type of bogie.

Two further features of this design may be noted; one was a rather peculiar idea involving the fitting of a spherical bush in the little ends of the connecting-rods, the object apparently being to permit of the crank axle moving slightly laterally without putting undue bending strains on the connecting-rods. In connection with this rather questionable idea, there was also a difference of ⅛in in the transverse distance between the cylinder centres and the distance between the centres of the crankpins, these dimensions being 24in and 23½in respectively. The second, a good feature, was the employment of clasp brakes for the coupled wheels, an arrangement copied from Worsdell's North Eastern engines.

These engines represented a powerful example of the type and successfully shared with the Deeley compounds the main line express duties. It may be recalled that two of the class, engines Nos. 992 and 998, took part in some exhaustive trials carried out by Sir H. Fowler, comparing the performance of simple and compound engines working with saturated and superheated steam, the results of which were communicated to the Institution of Civil Engineers, 1914. The simple engine working with saturated steam used 0·109 lb of coal per ton-mile and 0·94 lb of water, the water/coal ratio being therefore 8·62. The Deeley compound engine, No. 1039, also using saturated steam, consumed 0·0916 lb of coal and 0·793 lb of water per ton-mile, representing a water/coal ratio of 8·65. The compound, therefore, showed a large saving in both coal and water compared with the simple, confirming Sir H. Fowler's preference for compound loco-

*Particulars of Standard No. 1 Boilers, Non-Superheater and Superheater, Great Western Railway, 1903-1907*

| Boiler | Standard No. 1 | Standard No. 1 | Standard No. 1 | Standard No. 1 |
|---|---|---|---|---|
| Locomotive No. | 171 | 2901 | 4010 | 4011 |
| Date | 1903 | 1906 | 1907 | 1907 |
| Superheater | Non-superheater | Schmidt | Cole | Swindon |
| Working steam pressure, pounds per square inch | 225 | 200 | 225 | 225 |
| Tubes, number and diameter, outside, inches | 250—2 | 130—2 | 165—2 | 165—2 |
| Flues, number and diameter, outside, inches | — | 24—4½ | 18—4½ | 18—4½ |
| Superheater pipes, diameter, outside, inches | — | 1½ | 1½ | 1⅝ |
| Length between tube plates | 15ft 2⅛in | 15ft 2⅛in | 15ft 2⅛in | 15ft 2⅛in |
| Heating surfaces, square feet : | | | | |
| Tubes and flues | 1988·65 | 1485·96 | 1652·81 | 1652·81 |
| Firebox | 154·26 | 154·94 | 154·34 | 154·34 |
| Evaporative | 2142·91 | 1630·90 | 1807·15 | 1807·15 |
| Superheater | — | 307·52 | 269·04 | 300·0 |
| Combined | — | 1948·42 | 2076·19 | 2107·15 |
| Grate area, square feet | 27·09 | 27·09 | 27·09 | 27·09 |
| Superheater surface per cent of total heating surfaces | — | 15·71 | 15·0 | 14·26 |
| Total heating surfaces/grate area | 79·2 | 72·2 | 77·2 | 78·0 |

Engine No. 171, later No. 2971, was the first to have the standard No. 1 boiler with the standard working steam pressure of 225 lb per square inch.

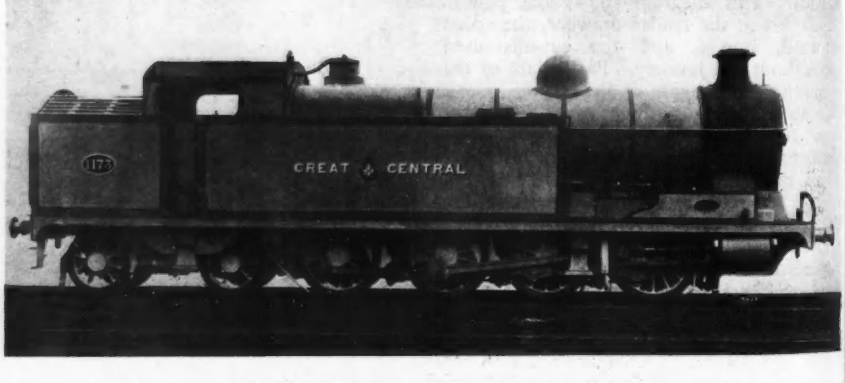


**Fig. 5—J. G. Robinson's eight-coupled, three-cylinder engine for shunting services**

† Boiler pressure later reduced to 200 lb per square inch.

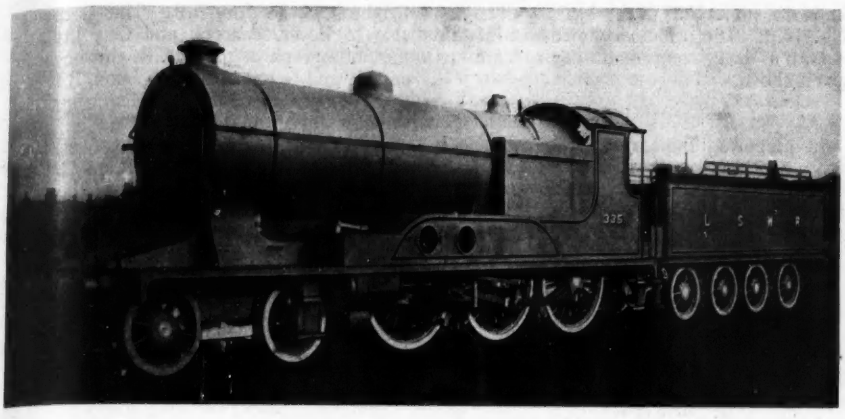

Fig. 6—D. Drummond's 4-6-0 engine for express services on the London and South Western Railway

motives, a view long held by the present writer. A description, together with an arrangement drawing, of these locomotives, appeared in THE ENGINEER of July 5, 1907. The principal dimensions are as follow :—

*Midland Railway 4-4-0 Type Express Locomotives, "990" Class*

| | |
|---|---|
| Cylinders : | |
| Diameter and stroke, inches... ... ... | 19×26 |
| Driving wheels, diameter, inches ... ... | 78½ |
| Heating surfaces : | |
| Tubes, square feet ... ... ... ... ... | 1421 |
| Firebox, square feet ... ... ... ... | 151 |
| Total, square feet ... ... ... ... ... | 1572 |
| Grate area, square feet ... ... ... ... | 28·4 |
| Steam pressure, pounds per square inch ... | 220 |
| Engine weight : | |
| On drivers, tons ... ... ... ... ... | 38·75 |
| Total, tons ... ... ... ... ... ... | 58·52 |
| Engine and tender, tons... ... ... ... | 104·45 |
| Rated tractive force, pounds ... ... ... | 22,400 |

## ROBINSON'S THREE-CYLINDER SHUNTING ENGINES

The remarkable eight-coupled 0-8-4 type shunting engines (Fig. 5), four of which were built in 1907 by Beyer, Peacock and Co. from J. G. Robinson's designs, are of interest more particularly because they attracted attention to certain advantages offered by the three-cylinder locomotive. It is true that George Stephenson designed and R. Stephenson and Co., of Newcastle on Tyne, built a locomotive with three cylinders so long ago as 1846, and even before that, in 1839, Isaac Dodds patented a form of three-cylinder engine. These early examples of the type had, however, no influence on subsequent designs, for, in fact, nothing further was done till, in 1902, James Holden, of the Great Eastern Railway, built at Stratford his large ten-coupled three-cylinder tank engine, intended for heavy suburban passenger traffic. No further attention was given to the three-cylinder simple expansion locomotive for some five years when, in 1907, J. G. Robinson by introducing his three-cylinder engines again directed attention to the advantages offered by this cylinder arrangement, since so largely in evidence.

Obviously, these remarks refer only to simple expansion cylinders as distinct from F. W. Webb's and W. M. Smith's three-cylinder compound systems, already well known. The Robinson engines for the Great Central Railway were specifically built for heavy shunting duties at the extensive Wath Concentration Yards near Barnsley, only recently completed, and the use of three cylinders with cranks spaced at 120 deg. was decided upon as being particularly advantageous for "hump" shunting when heavy mineral trains have to be propelled at low speeds over the humps. In designing these engines the standardisation of certain details was kept in view and as many parts as possible were made to conform with similar details of Robinson's eight-coupled tender locomotives then in main line freight services. The three cylinders, 18in by 26in, were arranged one between the frames driving the second pair of coupled wheels through a single-throw crank axle, the outside pair driving the third pair of coupled wheels, as is shown by the accompanying illustration of engine No. 1173.

Three sets of Stephenson's valve gear between the frames actuated slide valves, one set for the centre cylinder having the eccentrics fitted on the crank axle while the other two sets had their eccentrics mounted on the third coupled axle. Steam reversing gear was provided. The design as a whole presented a good example of a locomotive built for a special and important service, which, generally speaking, has not been given really modern steam power. Some time later Maunsell designed some up-to-date three-cylinder shunters for the Southern Railway, in 1929, and Hawkesworth built at Swindon some "round the clock" shunters for the Great Western in 1949 ; otherwise, little or nothing has been done to provide a really first-class steam shunting engine. The dimensions of Robinson's Great Central engines are as follow :—

*Great Central 0-8-4 Type Three-Cylinder Shunting Engines*

| | |
|---|---|
| Cylinders, three : | |
| Diameter and stroke, inches... ... ... | 18×26 |
| Drivign wheels, diameter, inches ... ... | 56 |
| Heating surfaces : | |
| Tubes, square feet ... ... ... ... ... | 1778 |
| Firebox, square feet ... ... ... ... | 153 |
| Total, square feet ... ... ... ... ... | 1931 |
| Grate area, square feet ... ... ... ... | 26 |
| Steam pressure, pounds per square inch... | 200 |
| Engine weight : | |
| On drivers, tons ... ... ... ... ... | 73·6 |
| Total, tons ... ... ... ... ... ... | 96·5 |
| Tanks : | |
| Water capacity, gallons, Imperial... ... | 3000 |
| Bunker : | |
| Coal capacity, tons... ... ... ... ... | 4 |
| Rated tractive force, pounds ... ... ... | 38,350 |

## DRUMMOND'S FOUR-CYLINDER EXPRESS ENGINE

For passenger services on the London and South Western, Drummond brought out a revised version of his 4-6-0 four-cylinder engines of 1905. One engine only, No. 335 (Fig. 6) was built in 1907, followed by others in 1908. Though generally similar in all main details to those built in 1905, the new engine had larger cylinders, 16½in diameter, as against 16in, and the outside pair, instead of having slide valves placed below the cylinders, were given piston valves arranged above, operated by Walschaerts valve gear, also used for the earlier engines. The inside cylinders, except for the difference in the diameter, were in all other respects as before and had slide valves between the cylinders operated as before by Stephenson's valve gear direct in the normal manner.

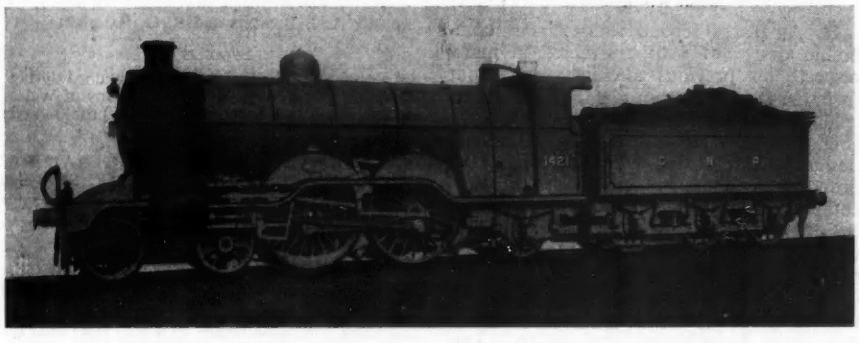

Fig. 7—Great Northern four-cylinder, compound express locomotive—H. A. Ivatt

Like that previously built, the design incorporated Drummond's special features, such as his arrangement of cross water tubes in the firebox in two nests of fifty-six 2¾in external diameter tubes, contributing 357

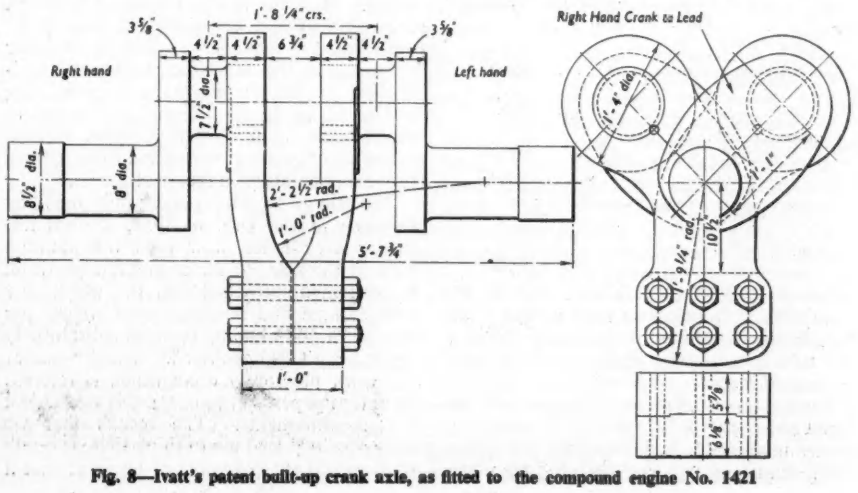


Fig. 8—Ivatt's patent built-up crank axle, as fitted to the compound engine No. 1421

square feet of heating surface to the firebox, making the total 517 square feet; further feed water heating apparatus was provided in line with Drummond's practice, including two steam pumps drawing hot feed from a heater in a well in the bottom of the tender water tank. The heater was fitted with sixty-five tubes, 18ft in length and 1¼in diameter, through which passed exhaust steam taken from a branch on the main exhaust from the cylinders. The tubular heating surfaces amounted to 382 square feet. Any steam not condensed in the heater tubes escaped in a pipe at the rear of the tender.

A large eight-wheeled, double-bogie tender was fitted, having a tank capacity of 4500 gallons of water and a loaded weight of 49 tons. The chief dimensions of this engine were as below :

*London and South Western Railway Four-Cylinder 4–6–0 Type Express Passenger Locomotive*

| | |
|---|---|
| Cylinders, four : | |
| Diameter and stroke, inches ... ... ... | 16½ × 26 |
| Driving wheels, diameter, inches ... ... | 72 |
| Heating surfaces : | |
| Tubes, square feet ... ... ... ... ... | 2210 |
| Firebox cross tubes, square feet ... ... | 357 |
| Firebox, square feet ... ... ... ... | 160 |
| Total, square feet ... ... ... ... ... | 2727 |
| Grate area, square feet ... ... ... ... | 31·5 |
| Steam pressure, pounds per square inch... | 175 |
| Engine weight : | |
| On drivers, tons ... ... ... ... ... | 56·05 |
| Total, tons ... ... ... ... ... ... | 76·65 |
| Tender, tons... ... ... ... ... ... | 49·0 |
| Total locomotive, tons ... ... ... ... | 125·65 |
| Rated tractive force, pounds ... ... ... | 27,500 |

### Great Northern Four-Cylinder Compound Engine

H. A. Ivatt's second four-cylinder compound design of 1907 resembled in many respects his previous attempt, turned out from the Doncaster shops in 1905. Like this engine, No. 292, the new one, No. 1421 (Fig. 7), was the standard "Atlantic" design, "251" class, with the large wide firebox boiler altered to provide four cylinders compounded.

For No. 1421, the two outside h.p. cylinders driving the trailing pair of coupled wheels were 13in diameter by 20in stroke, and the inside pair of l.p. cylinders driving through a crank axle the leading coupled wheels were 18in diameter by 26in stroke. This engine had Walschaerts valve gear, four sets, one set for each cylinder. The crank axle was of novel construction, patented by Ivatt, in which the two webs of each crank were extended backwards and so shaped that the extensions could be bolted together to form a balance weight. This unusual design of built-up crank axle is shown by the accompanying drawing (Fig. 8), which, together with the photograph of this second Ivatt compound (Fig. 7), has been furnished by the writer's friend, B. Spencer, of Doncaster. The boiler heating surfaces, as given in the table below, differ from those of the

*Great Northern Railway Four-Cylinder Compound Engine No.* 1421

| | |
|---|---|
| Cylinders, four : | |
| High-pressure, two : | |
| Diameter and stroke, inches ... ... | 13 × 20 |
| Low-pressure, two : | |
| Diameter and stroke, inches ... ... | 18 × 26 |
| Ratio... ... ... ... ... ... | 2·49 |
| Driving wheels, diameter, inches ... ... | 80 |
| Heating surfaces : | |
| Tubes, square feet ... ... ... ... ... | 2208 |
| Firebox, square feet ... ... ... ... | 143·6 |
| Total, square feet ... ... ... ... ... | 2351·6 |
| Grate area, square feet ... ... ... ... | 30·9 |
| Steam pressure, pounds per square inch... | 200 |
| Engine weight : | |
| On drivers, tons ... ... ... ... ... | 36 |
| Total, tons ... ... ... ... ... ... | 69·1 |
| Tender, tons... ... ... ... ... ... | 40·9 |
| Total locomotive, tons ... ... ... ... | 109·0 |

standard "251" class boiler, due to the front tube plate being set back a little in the barrel, so shortening the distance between the tube plates, thus reducing the tubular heating surfaces.

Particulars of the performance of the former engine, No. 292, were given in a paper contributed by H. A. Ivatt to the Institution of Mechanical Engineers, 1907, but the writer knows of no records of the working of engine No. 1421. The principal dimensions of this —Ivatt's last compound engine—are as given above.

### Acknowledgments

In preparing these recollections of 1907, the writer has received valuable help from many friends, who include B. Spencer, of the Doncaster office of the C.M. and E.E., N.E. and E. Region, B.R.; also G. M. Burrows, of Brighton, S. Region, B.R. Thanks are due also to Beyer, Peacock and Co., Ltd., for the photograph of the G.C.R. three-cylinder engine, and to the Western Region, B.R., for the photographs of the G.W.R. engines and the drawing of the "Star" class.

Acknowledgment is also made of assistance kindly given by Harold Holcroft and C. R. H. Simpson. For the photograph of the M.R. engine No. 999 the writer is indebted to J. F. Harrison, C.M.E., L.M. Region, B.R., Derby.

# Iron and Steel Institute

## AUTUMN MEETING

### No. I

THE autumn meeting of the Iron and Steel Institute was held in London on Tuesday, September 24. The president, Mr. A. H. Ingen-Housz, was in the chair.

A resolution was unanimously carried for the nomination of Mr. C. R. Wheeler, vice-president, for election as the next president of the Institute.

After dispatching the official business the meeting turned to the discussion of technical papers. The first two of these were considered together.

### INFLUENCE OF SLAG PROPERTIES ON PIG IRON COMPOSITION

By A. J. Burgess and B. G. Baldwin

#### Synopsis

An account is given of the results obtained during a blast-furnace trial at the Steel Company of Wales to study the relation between metal composition and slag properties.

### THE LIQUIDUS AND HIGH-TEMPERATURE PROPERTIES OF BLAST-FURNACE SLAGS

By B. G. Baldwin, B.Sc., Ph.D., A.R.I.C., D.I.C.

#### Synopsis

The results of the measurements of the liquidus temperature of over 150 blast-furnace slags are described, showing that the actual temperatures are close to those predicted on the assumption of the slag being composed wholly of CaO, MgO, $Al_2O_3$, and $SiO_2$. The experimental technique permits the direct observation of crystal growth and movement in the molten slag at temperatures up to 1750 deg. Cent., and leads to conclusions regarding the relation of viscosity to the behaviour of the slag around the liquidus. These conclusions were checked with viscosity measurements on blast-furnace slags. The relationship between temperature and viscosity, and the application of the technique to problems of slag utilisation, are also discussed.

#### Discussion

Professor F. W. Richardson (Imperial College of Science and Technology) : One of the most interesting points in the first paper is the high magnesia contents of the slags, and the very excellent sulphur partition ratios. How far is this improved partition a matter of the chemistry of slag metal partition, and how far a question of other properties of the slag which enable the equilibrium of sulphur partition between slag and metal to be more nearly approached in the furnace ? In normal practice, we are out of equilibrium as calculated from laboratory experiments by a factor of 2 or 3.

According to the paper published by Osborne in the U.S. in 1954, it does not matter very much how high the alumina runs in the slag, so far as sulphur partition is concerned, provided that the weight per cent of lime and magnesia over weight per cent silica and alumina remains substantially the same. This does not fit in with some of the work previously done which is referred to in that paper, but to check this we made a few measurements. The results that we have obtained lead me to think that we ought to disregard the statement of Osborne that it does not matter much at what alumina level you work provided that you choose one of these relatively low melting points.

Turning to the other paper, on the very elegant and neat technique for measuring the liquidus of these various blast-furnace slags, I should like to ask Dr. Baldwin whether he has made measurements with steel-making slags. With the steel-making slags, you have a lot of iron oxide and this may raise complications. Thanks to Dr. Baldwin's assistance we have found that this elegant method is not suitable for studying high manganese slags because the slag is opaque.

Of course, I know that one should not mention lead in a place like this, since lead melts at 325 deg., which is rather a despicable temperature ; but we did make tentative studies with lead slags with this same equipment, because then you can see through them nicely and are not worried by the attack of the platinum by the lead. The trouble is that with such a small amount of material, and such a relatively high surface to volume ratio, any volatile constituents rapidly move out of the slag. In our experiments the melting point went up and up, and lead oxide was escaping the whole time. This might be a difficulty with other volatile oxides if attempts were made to use the apparatus for a wider range of slags.

Monsieur F. Kozakevitch (Institut de Recherches de la Siderurgie, France) : Dr. Baldwin's paper is of particular interest in regard to those slags the liquidus point of which cannot be determined approximately from the diagrams of Osborne, or other diagrams of simplified quaternary systems. It is a very rapid and convenient method, and it has already been used in France. Dr. Baldwin measured for IRSID several slags. These basic slags had a lime-silica ratio approaching 1·6 or perhaps 1·58. We were convinced in past years that the so-called high viscosity of these slags was not a true viscosity, but simply due to the presence of suspended matter in the melted slag which goes out of the furnace—probably calcium silica. Our measurement always showed a very low viscosity, and then a very abrupt increase at points which we always considered approached the liquidus point. Dr. Baldwin confirmed that our slags became heterogeneous at a point which was 40 deg. or 50 deg. over the temperature of the slags flowing out of the furnace as measured in the actual operation in the plant.

We found from the behaviour of our viscometer at high temperatures that these slags appeared to be slightly heterogeneous even at temperatures much higher than what could be reasonably considered as their liquidus point, and this slight heterogeneity of the slags continued up to 1650 deg. Cent. and even over. So we supposed that this

slight heterogeneity was due to the presence of carbides, which do not dissolve in slags. Dr. Baldwin was able to see these particles in our slags.

Mr. J. T. Shaw (British Coal Utilisation Research Association): Dr. Baldwin's practical confirmation of Osborne's ideas is of considerable interest to the British Coal Utilisation Research Association, where experiments are being conducted on the flow properties of coal slags.

We have been looking for a rapid and, if possible, micro-method of obtaining comparable information. The success of Dr. Baldwin, as set out in his paper, encouraged us a great deal and we have made a number of experiments.

Certain difficulties which do not appear with blast-furnace slags were encountered in our work. As you may have noticed on the film, there is some self-luminosity with blast-furnace slags. With coal slags this is very much worse. However, if you quench the bead you usually find that it is reasonably transparent when it is cold.

The results of our measurements, when compared with the set of viscosity graphs which have been prepared for us, show that Osborne's assumption unfortunately cannot be extended to coal slags. Several of the slags that we studied are very viscous at the liquidus temperature and although, owing to the steepness of the viscosity against temperature curves, a small upward adjustment of the liquidus temperatures would bring them into harmony with his assumption, that small margin of error makes the mere measurement of liquidus temperatures a poor test of viscosity.

So far the observations that we have made are not inconsistent with the viscosities measured in a conventional viscometer.

Mr. J. H. Welch (Building Research Centre, D.S.I.R.): Dr. Baldwin's paper shows what can be accomplished with a remarkably simple technique. There is no question here of inferring what may or may not be taking place in a slag at various temperatures; the observer has the satisfaction of seeing for himself. Admittedly the volume of a slag which is being observed under the microscope is so minute that it comprises only about 1/100,000 millionth part of the slag present in the furnace, and one may ask whether such a small sample can be regarded as representative. I can only answer that, from the comparative results reported in this paper, using a range of laboratory techniques, the results show a remarkable degree of consistency—as much as one can expect using any laboratory method to simulate a full-scale process.

At the Building Research Station we are becoming more and more convinced of the widespread usefulness of this method. We have developed a modified technique for working at temperatures up to 2300 deg. Cent., and we have also a high-temperature X-ray camera founded on the same principle.

Mr. K. C. Sharp (Steel Company of Wales, Ltd.): The recent work of Osborne and his co-workers has been of great assistance in indicating the range of high basic slags which can be used with perfect safety and result in the manufacture of very low sulphur iron associated with low silicon. In that connection, one must remember that the blast-furnace operator is not presented with very easy controls. In recognising Osborne's work, we ought not to forget Dr. Colclough's work in 1936. In that instance, attention was drawn to the method of burdening to produce the most economic slag composition. In our own case, we have set ourselves the target of producing very low sulphur iron at reasonable blast-furnace economy. As an indication of what can be achieved by such an optimum burdening policy, since 1955 over 17,000 casts have been made at the Margam blast-furnaces. Almost 14,000, or over 81 per cent, of them have been within the specified target of silicons 0·4 to 0·7 mix and sulphurs below 0·03 per cent. Some 60 per cent of the sulphurs would be below 0·02 and 98 per cent would be below 0·05.

Dr. B. G. Baldwin (in reply): Professor Richardson's comments on the work of Osborne, and the contention of Osborne that within the alumina level study there appeared to be no valid reason for working at any particular alumina level, are, I think, true; but I think one must remember that it can now be shown to be true as a result of work that has been done subsequent to the original paper.

*(To be continued)*

# Lubrication and Wear

*On Tuesday, Wednesday and Thursday of this week a Conference on Lubrication and Wear was held by the Institution of Mechanical Engineers in London. A very large number of papers were presented, so large, indeed, that they were grouped under various headings, and "reporters" for each group summarised them in order to open discussion upon them. The subjects for discussion ranged from the fundamental nature of friction to wide technological applications of theoretical and practical knowledge. Below we make reference to some of the points brought out by some of the papers.*

CONSIDERING first basic knowledge, it will be recalled that the simple adhesion theory of friction assumed that the load between two bodies was divided among a number of asperities whose total area was determined by the yield pressure of the softer material. If there was good adhesion between surface asperities, the friction force was found by multiplying the adhered area by the shear strength of the weaker of the two bodies. Then the coefficient of friction was proportional to the ratio of the yield pressure to the shear strength of the softer material and was therefore independent of the load; thus it became constant for any material. This simplified picture was now, according to a paper presented at the conference, regarded[1] as inadequate because, for most metals, it would lead to a coefficient of friction of approximately 0·2 instead of to about three times that value, which was observed for most clean metals sliding in air.

Study of models of idealised asperity contacts had revealed that, when the strong adhesion occurred at the regions of real contact between metal surfaces, the force required to shear the friction junctions so formed was, in fact, very close to the product of the cross-sectional area of the junctions and the bulk shear strength of the material. However, the area did not appear to depend on the load in the simple way formulated above. The relationship was more complicated and depended rather critically on the geometry of the friction junctions and the elastic deformation around the plastic zone. The coefficient of friction was more nearly 3, a value which was only achieved under such idealised conditions as very clean materials sliding in a very intense vacuum. When models of "unclean" asperities were studied, the results of coefficient of friction were more in accord with experience. This situation may well represent what happens in most lubricated systems and if this is so we must think in future in terms of a "plastic deformation" theory of wear rather than of the "adhesive" theory as heretofore.

There were at least five ways in which a surface asperity might be in contact with another surface.[2] Only one of these involved physical adhesion between the two surfaces. By assuming appropriate conditions, e.g. the predominance of either plastic or elastic deformation at the points of contact, values of the coefficient of friction might be calculated which showed agreement with experimental results. A particularly important point about the coefficient so calculated was that its value was not a constant as was usually assumed, but that it might, in certain circumstances, depend on the load.

In addition to such theoretical studies, the full range of modern techniques—electron microscopy,[3, 4] and the use of radioactive tracers[5]—was displayed in the conference, but the newly won knowledge so far provided by these techniques is, however, somewhat disappointing. Studies of the nature of fretting,[6, 7] however, revealed the importance of the initial scratching type of damage and the way in which this is transformed into considerable "fretting" by the presence of oxidised debris. It had been demonstrated that the wear resistance of materials was markedly affected by the microstructure as distinct from the bulk hardness. In mild steel, for example,[8] the pearlite could be regarded as being more wear resistant than the ferrite and the cementite components of the pearlite were shown in some instances to have acted as cutting elements. Under severe conditions, metallographic changes could occur leading to a hardening of the surface[9] and might sometimes enhance subsequent resistance to scuffing.[10]

According to other contributions to the conference, the plain journal bearing, which occupied such an important place in engineering, was not always designed with strictest regard to hydrodynamic theory. Nevertheless, successful operation depended on the relative motion of the two surfaces creating pressure within the oil film sufficient to support the loads without physical contact between the shaft and its bearing. Whilst the fundamental equations governing the generation of this pressure were well understood, considerable controversy existed as to the limits to be assigned to the integration of pressure around the bearing. It had been assumed in most published papers heretofore that the film ceased to exist under a condition where pressure fell to atmospheric and the pressure gradient along the bearing also became zero. New techniques for studying bearings[11, 12] were, however, reported, whereby it was possible to render visible the extent of the oil film, and these studies, together with pressure measurements, revealed that some negative pressure could exist and therefore that the theoretical predictions of load capacity might be less precise than had hitherto been believed. Moreover, it was more important that basic knowledge should be presented to the drawing-offices for use in a convenient manner than that it should be absolutely precise, but presented in such a complicated form that no practising designer would ever have time to unravel the formulæ and apply them to his own particular case. A particularly useful approximation

involved the neglect of velocity differences in the plane of motion arising from the bearing pressure itself. When this approximation was made, most of the design parameters affecting bearing operation became simple algebraic formulæ. Design procedures[13] were therefore given at the conference which should enable progress to be made in bearing design. Some of the dividends which were payable for such progress were exemplified by the application of modern narrow bearings to marine turbines and gears.[14] A direct comparison showed that in a set of machinery with bearings of conventional design, the overall length was 16ft 1in. By the application of bearings designed in accordance with modern theory this length was reduced to 14ft 3in. It was clear that narrow bearings—that is, bearings whose axial width was equal to or less than half the diameter of the shaft, had inherent advantages over the longer bearings which were still employed from time to time. Another troublesome aspect of bearings was that of bearing whirl. It was indicated that, provided the load on a bearing was sufficient to cause the lubricant film to be discontinuous around its periphery, little trouble from this cause was likely to be experienced.[15]

In contrast to considerable progress in the design and construction of the plain bearings, the conference revealed comparatively little advance in ball and roller bearing practice. Papers generally related to the lubrication and to the failure of materials of bearings[16] but very little information came from ball-bearing industry itself. Greatly increased duties have been demanded by the advent of the gas turbine and this has resulted in considerable research taking place in national research organisations and in the laboratories of the larger engineering firms.[17] False brinelling is a form of wear arising from circumstances when a rolling bearing is subject to vibrations when stationary or when it performs only small turning movements. This form of wear gives rise to cavities which resemble brinell test indentations, hence its name. It is, of course, related to fretting corrosion. A paper from one of the leading bearing manufacturers in the world[18] concluded with the discouraging statement that there appeared to be no preventive for this kind of wear other than the suppression of the vibration.

Distinct possibilities exist for eliminating liquid lubricant altogether either by constructing one or both of the running surfaces of special low friction material or alternatively by treating both materials chemically to provide an anti-friction surface. Polytetrafluoroethylene (PTFE) is a plastic which has been shown to have basically good anti-friction and wear properties. It has, however, low mechanical strength and poor thermal conductivity, so that when used alone as a bearing surface only limited loads and speeds can be withstood. However, according to another paper, special materials had now been developed[19] in which the PTFE was impregnated into a porous matrix to give two interlocked sponge networks, one of PTFE and the other of metal. This kind of bearing material could be used for temperatures up to 250 deg. Cent. with no form of oil lubrication whatsoever. This property, of course, was particularly desirable where conventional lubrication was impossible or undesirable. The coefficients of friction obtainable with this material, whilst low, were higher than with complete fluid film lubrication, so that it would not be wise to predict the eventual replacement of conventional bearings by PTFE/bronze bearings. Undoubtedly, however, they had a great field of use which was at present relatively unexplored. Phosphating a surface was shown to facilitate running-in primarily by encouraging hydrodynamic conditions.[20] If, after phosphating, the surface was treated with molybdenum-disulphide which was bonded on either by syrup, PTFE or resorcinol resin, a low-friction wear-resistant surface was obtained.[21]

The nature of solid films found on surfaces had a very great bearing on the friction and surface damage.[22] Films of graphitic carbon on cast iron, nickel oxide on nickel alloys and FeO and $Fe_3O_4$ on ferrous materials were reported to be beneficial. However, $Fe_2O_3$ was definitely detrimental. Films produced by reaction with sulphur and chlorine were both effective but the benefits obtained by molybdenum-disulphide were confined to temperatures below 500 deg. Cent.

One of the most pressing requirements, particularly in aircraft engines, was for lubricants which could withstand high temperatures. The synthetic diesters had been proved particularly useful in this connection but certain formulations had given rise to premature pitting of ball bearings due to corrosive effects.

With the increasing rotational speeds of modern machinery it had become possible to consider air as being a substance of sufficiently high viscosity to provide hydrodynamic lubrication of bearings.[23] It had been shown that, without providing any external source of air pressure, loads might be carried of approximate magnitude of 1 lb per square inch per 1000 r.p.m.[24] Under steady loads approaching this magnitude bearings operated very silently, very steadily, but when loads were very light troubles with whirling were experienced.

Mechanical engineering practice, particularly in the transport field, owes a great deal to a partnership of mechanical design and chemical technology. Occasional features in which harmony between the two arts had not been achieved were mentioned during the conference.[25] An example of intensive design leading to overloading and failure was the development of the modern eight-cylinder V type automobile engine in the United States. Here, failure of the valve tappets and cams due to early wear and pitting occurred, and development of a sulphur-phosphorus additive was highly effective in preventing the failure of carburised steel tappets. This was to be regarded as a mere palliative, although it has been put to extensive use in automobile lubricants, and if the tendency for higher speed continued the push-pull system of valve actuation should be re-examined. This provided an excellent example of the wisdom of combining good mechanical design with good lubricant technology.

One of the most severe wear problems remaining was that of the cylinder bores of internal combustion engines. Considerable evidence was adduced to show that this wear was largely corrosive in character.[26] The use of additives having a high alkalinity was shown to result in a considerable reduction in wear rate. The relationship between mechanical design and lubricant technology was exemplified in quite a different field.[27] This was in marine geared steam turbines where the tendency to conserve space has resulted in a reduction of the size of the marine turbine reduction gear sets leading to higher tooth loading. By automobile standards this loading was still relatively far from severe. However, it was desired to use the same lubricant for steam turbines and this resulted in a contradictory requirement. Turbine oil must be stable whereas extreme pressure properties demanded chemical reactivity and therefore some instability. The development of additives which were only effective at high temperatures had enabled the problem to be solved.

Second in importance as a wear problem to the cylinder bore was the crankshaft of internal combustion engines. It was demonstrated that this wear arose from hard particles which embedded themselves in the white metal bearing lining, then acting as a lap for the shaft.[28] The amount of wear which occurred was shown to be governed by the nature of the bearing liner and the extent to which embedded particles of the liner surface projected into the journal. Some engines were shown to be more prone to wear than others, inertia loads tended to be more severe than gas loads and long bearings tended to give rise to severe conditions of edge-loading. Thus mechanical design, coupled with the appropriate metallurgical treatment of a shaft and white metal, rather than modifications of the lubricant, were, in this instance, the prerequisites of progress.

The effect of the viscosity of crankcase lubricants on the fuel consumption of road vehicles had been studied statistically.[29] It appeared that considerable advantage was obtained by reducing the viscosity to that of a proprietary S.A.E. 10W oil, but that further reductions were not justified. A study of alternative lubricants for worm-driven axles showed viscosity to be an unimportant factor. However, changing from a mineral back-axle lubricant containing additives to a proprietary lubricant containing a blend of castor oil and a synthetic-ester with appropriate oxidation inhibiting additives showed a clear saving on fuel consumption. Oxidation-inhibited castor oil also showed better frictional results than the conventional lubricant.

In addition to the foregoing subjects, the conference ranged over such topics as the lubrication of fluid seals and the effect of cutting oils. Taking the proceedings as a whole, the Institution is to be congratulated on the balance it has achieved between academic and applied studies and between the different branches of mechanical engineering.

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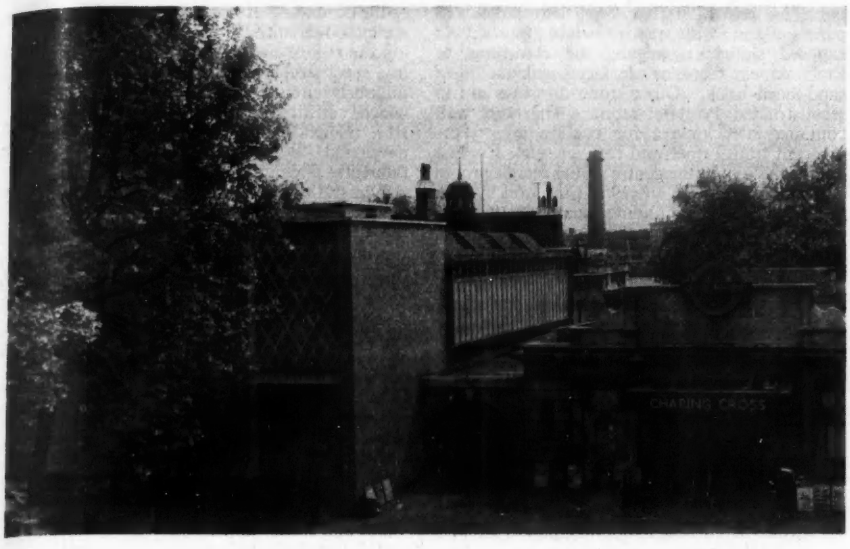


# London Transport Substation at Charing Cross

*A new substation is being built to feed the District, Northern and Bakerloo lines at Charing Cross. It is being equipped with six 1500kW mercury arc rectifier sets, with space for two more. Each 1500kW set is of unit construction, the transformer being mounted below the associated rectifier, and occupies only 9 square feet of floor space. Without interfering with the train service, this plant is being commissioned in stages, to take over from the existing substation, which is fifty-two years old and is equipped mainly with 1500kW rotary converters. The new substation and some aspects of the changeover are described here.*

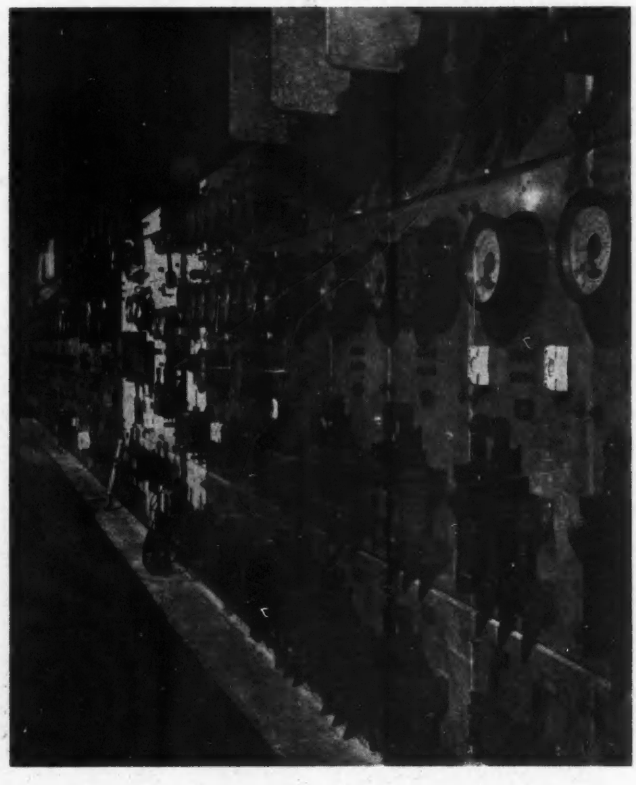
LAST week we visited the new substation which will eventually feed three Underground lines at Charing Cross—the District, Northern and Bakerloo lines. At present the new equipment is operating at about two-thirds of its ultimate capacity, four of the six sets of mercury arc rectifier equipments being in service. Changeover from the old plant to the new is being done in stages to avoid any interruption to passenger service and the operation should be completed early next year.

The old substation, illustrated below, was built fifty-two years ago; it is entirely below ground level and is fed from Lots Road power station at 33⅓ c/s. Originally the main installation consisted of four British Westinghouse 1500kW rotary converters. A fifth rotary converter of the same rating was added ten years later and a sixth, having a capacity of 2500kW, was installed in 1921, when the substation was the largest on the underground system. The incoming a.c. supply to the rotary converters was stepped down by single-phase transformers connected in banks of three, or six in the case of the later converter sets. The transformers, as illustrated below, were installed in a gallery above the main switchboard; they were supplied by the then British Westinghouse Company. Each transformer is an ironclad unit with forced air cooling on an open circuit system. The d.c. switchgear, part of which is shown in Fig. 5, is the original equipment, made by British Westinghouse and is still in service, together with five of the rotary converters.

The new substation, which is above ground, is fed from Greenwich power station at 50 c/s, via Aldgate switch-house, and is being equipped with rectifying units totalling 9000kW, leaving space for two more 1500kW units.

At Charing Cross, as at all London Transport's recently modernised substations, unit construction has been adopted for the new rectifiers, each transformer being mounted in a cubicle below the associated rectifier. This arrangement offers the maximum portability and flexibility in assembly and enables the sites available to be fully utilised. The design has been evolved from the original portable units specially produced in 1948 by the Hackbridge and Hewittic Electric Company, Ltd., to meet the requirements of the London Transport railway services.

Four years ago, shortly after the order for the new Charing Cross substation plant had been placed, a serious breakdown in the transformers of the largest rotary converter put that set completely out of action. Because of the impending replacement programme, the cost of repairing the transformers could not be justified, but to compensate for the 2500kW loss in station capacity two of the original 1000kW portable rectifier units were installed and coupled together electrically to form one 2000kW set. The damaged transformers were removed from the building, but the site difficulties and necessity for maintaining the power supply precluded the removal of



(Left) The rotary converters in the 52-year-old substation are below ground level. The gallery above the open type switchboard on the right carries the transformers which are metal clad, forced-air-cooled single-phase units connected multiphase. (Right) The original d.c. traction switchgear which is still in service

the rotary converter and all that could be done was to pull the armature partially out of the machine, thus helping to provide space for parts of the portable rectifier units. The two rectifier sets were installed piecemeal in existing spaces ; some parts are alongside the defunct rotary converter and some on the switchboard gallery. Because of the restricted access and necessity for maintaining passenger traffic, the whole operation took nearly three months to complete, whereas, on a clear site the first of these portable units was put into service in three days.

Apart from housing the new electrical plant, the new building is designed to allow for improved ventilation of the tube tunnels in the area at a later date. The District line platforms and old substation, over which the new building has been erected, were not designed to take any substantial additional loads. Therefore the railway retaining walls, built in 1869, and part of the roof steelwork of the original substation had to be strengthened ; a new girder, 65ft long, spanning the platforms and tracks, had to be placed, and additional underpinning steel was required beneath the stanchions carrying one of the girders of the " Exit " footbridge.

However, as the new substation plant is practically free from vibration and does not need massive foundations, as would be the case with heavy rotary converters, it has been possible to install the new equipment on suspended floors.

In the new building itself, designed by Mr. T. Bilbow, architect to London Transport, the load carrying has been accomplished by using lightweight construction wherever possible and by placing new girders above the level of the footbridge walls, so that no loading of the new walls or roof is transmitted to the existing girders. The new building is to the left of the passenger exit as illustrated on page 487.

Over the rectifier room, where the heaviest machinery is installed, a clear roof span is essential and this requirement favoured the use of a lightweight roof, consisting of light steel lattice beams carrying four aluminium monitor ventilators. The intermediate panels of the semi-flat roof are of aluminium decking, with lightweight waterproofing material as finish and a fireproof topping. As the west wall of the rectifier room is clearly visible from Hungerford Bridge, special consideration was given to the architectural aspect. To reduce weight, a light steel lattice framing was used, and clerestorey windows are provided at high level, with asbestos panelling below. Apart from two large wall panels faced with precast slabs finished in exposed shingle aggregate, the elevations to Embankment Gardens are faced with an Essex sand-faced brick. Other stone dressings are in reconstructed Portland stone. The west wall contains inlet louvres for cooling air to the adjacent transformer and rectifier sets. Cooling air for the sets in the centre of the rectifier room is drawn in through louvres at roof level by four 7500 cubic feet per minute axial flow fans, at control room floor level, and is delivered through ducting to the area immediately behind these sets. Heated air leaves the building via the monitor vents in the roof.

The ground floor of the new building houses the rectifiers and transformers and the high-voltage a.c. and the d.c. switchgear, while the rectifier relay panels, lighting and signal switchgear, batteries, battery distribution switchboards and battery charging units are installed on the upper floor. The control room, from which the power and signalling supplies for a large area will eventually be supervised, is also on the upper floor. It will, however not be so equipped for some time ; control of the new substation will be effected from new temporary panels situated in an adjacent room.

The new equipment is similar to that installed at Bond Street in 1954 and it, too, was made and installed by the Hackbridge and Hewittic Electric Company, Ltd., to the requirements of Mr. T. S. Pick, chief electrical engineer of London Transport.

### Rectifiers

The new plant is designed for an ultimate capacity of 12,000kW, comprising eight rectifier sets each of 1500kW rating ; however, only six sets are being installed in the first instance, a nominal 9000kW being considered adequate for the prevailing needs. These, of course, are capable of sustaining the short, heavy overloads normally called for with suburban railway equipments ; they comply with class III rating of BSS.1698 : 1950.

Each 1500kW set consists of a pair of 750kW half-units, each with its own transformer and each employing six-phase rectification. It is arranged, however, for the combined set to operate twelve-phase ; this is done by winding one transformer with a star primary, the other being connected in delta, so that the secondary phases of one are 30 deg. out of phase with those of the other. As at Bond Street, the transformers are closed-circuit, air-blast cooled, thus eliminating the risk of fire. Each transformer is housed in a sheet steel enclosure, in which the air is continuously circulated through a heat exchanger which constitutes a form of tubular radiator with an external cooling fan. Thus the heat developed in the transformer is dissipated indirectly and no dust or dirt is drawn into its windings. Part of the rectifier plant is shown below. The rectifier bulbs are mounted above the transformer housings. But for this layout, in which each 1500kW set covers a floor area only 9 feet square, it would have been impossible to house the required capacity of rectifying plant in the space available. The interphase transformers, fan control reactors and auxiliary transformers are located between the pair of main transformers forming a twelve-phase set.

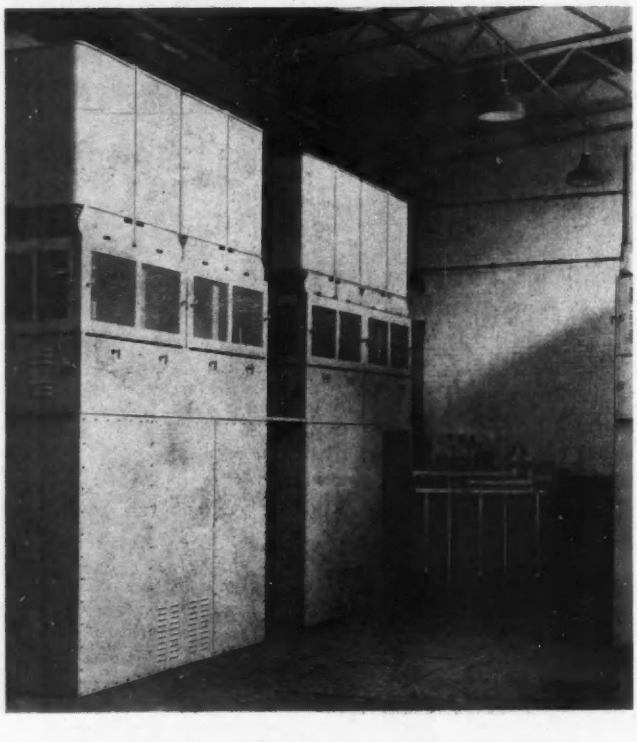
Linking facilities are provided so that one of a pair of half-units can be isolated, while attention is given to circulating fans or any other item, and the remaining half continues to give its 750kW output, the rectification then being temporarily six-phase. Removable gantries can be readily fitted to the cubicle framework for access to the bulbs and starter units.

### H.V. Switchgear

The high-voltage switchgear is by Switchgear and Cowans, of Manchester, and comprises a bank of fourteen " FB.31 " vertical-isolation, compound-filled units rated for 11kV ; these units serve three incoming feeders, seven rectifiers, two bus-section switches, one outgoing feeder, and one lighting transformer feeder. There is space for an additional unit and the switchboard is divided into three sections. Solenoid closing is provided for all the circuit breakers, which are fitted with arc control devices and have a tested rupturing capacity of 350MVA.

Instantaneous protection on the incoming feeders is by " Translay " relays, and back-up protection is given by inverse time overload and earth leakage relays. There is also frame earth leakage protection. Each incoming feeder has a voltmeter, ammeter and kilowatt-hour meter. The rectifier circuit breakers have over-current and earth fault protection and means for remote load indication.

Modernisation of this substation has entailed the provision of three new 11kV, 0·25 square inch, three-core, paper-insulated lead-alloy-



Two of the six rectifier sets. Each set consists of two half-units and the transformer of No. 6 half-unit is shown withdrawn from its enclosure

Truck type d.c. switchgear in the new Charing Cross substation. The positive switches are on the left of the aisle and the negative on the right

sheathed feeder cables from Aldgate to Charing Cross via the District Line tunnels, together with a pilot cable for "Translay" protection.

### D.C. Switchgear

The d.c. 630V switchgear is in two banks, the positive circuit breakers in one and the negative contactors in the other as illustrated; each positive circuit breaker faces the corresponding negative contactor. This equipment consists of truck-type draw-out units, made by Bertram Thomas (Engineers), Ltd., Manchester. There are twenty-five cells in each bank, but two are skeleton units and will be equipped if and when the other two rectifier sets are installed. One pair of these cells contains emergency trucks for standby use. The rating of the circuit breaker and contactor on each standby truck is 3000A.

Both the circuit breakers (which are high-speed equipments) and the contactors are electrically closed. Their ratings are 4000A for the rectifiers and 3000A for the outgoing feeders. The former trip only on reverse current—which would result from a fault in the associated rectifiers—and the tripping of any one of them opens the associated high-voltage a.c. breaker. The feeder circuit breakers do not reclose automatically after tripping on a fault or overload, but give an alarm at the controlling point; the operator then restores the supply at his discretion. The circuit breakers are closed by push-button control and are mechanically latched-in, the negative contactor following automatically. Similarly, on opening, the contactors follow the breakers, since their closing and holding circuits are completed via auxiliary contacts on the circuit breaker.

Two pairs of couplers of 4000A rating divide these twin switchboards into three sections, and initially two rectifier sets will feed into each section. Sections 1 and 3, however, have additional skeleton housings for the future rectifier units referred to previously. Section 1 has feeder circuit breakers supplying two northbound and two southbound sections of the Northern Line, and section 2 supplies four similar lengths of track on the Bakerloo Line. The east and westbound tracks of the District/Inner Circle Lines are supplied from section 3.

Each section of the main d.c. switchboard has its own voltmeter, mounted over the central gangway between the two banks, and each length of positive and negative busbar has surge arresters for discharging to earth any surge voltages that may develop on the system, and fuses capable of breaking the "follow-through" current should the arrester fail. An isolating switch ensures safety when replacing a fuse. Finally, each negative busbar has an earth fault relay. As both poles of the system are normally fully insulated, any considerable current leakage from the positive pole will lead to an increase in potential between the negative pole and earth. If this is sufficiently large the relay will operate and give warning that a fault has developed. This facility assists in locating faulty trains.

### Auxiliary Switchgear

Test panel equipment for the positive and negative d.c. trucks is mounted on the side wall of the building. For the present, a low voltage a.c. supply for station lighting and auxiliary purposes is obtained from an existing group of three single-phase transformers in the old substation at 220V, 33⅓ c/s, but later the system is to be standardised at 415V, 50 c/s, four-wire, and fed from a transformer to be installed in the new building. The new switchboard is on the upper floor and is designed for the future conditions, but operates temporarily on the existing system. It incorporates six Switchgear and Cowans air-break double-tier draw-out units. The incoming circuit breaker is rated at 1200A and the feeder circuit breakers at 400A.

Facing this switchboard is the signal switchboard, which is in two sections; one operates at 600V, single phase, and is fed from a transformer in the old substation for supplies to District and Bakerloo Lines; the other gives a 440V supply for the Northern Line and for tunnel telephones. After the main conversion to 50 c/s, the frequency of the supply to all signalling equipment will be maintained at 33⅓ c/s to prevent inadvertent operation of signals by possible fault current from any 50 c/s power supply system. The retention of the 33⅓ c/s supply will necessitate the installation of motor generators or some other form of frequency-changer at a later date.

### Cables

The track feeder, escalator, lighting and pump feeder cables, which are the responsibility of the signal engineer, are being lengthened and re-routed to the new substations, the new cabling being non-draining, pre-impregnated, paper-insulated, with lead sheathing. Track feeder cables are 1·4 square inches single-core, escalator cables 0·4 square inch concentric, while the lighting cables are three-core 0·25 square inch shaped conductor cables; lead alloy sheathing is to alloy "C," B.S.S. 1938. A mechanical sealing end, developed by the signal engineer, is being used for terminating the track end of each track feeder cable. Existing cable runs are being used and modernised where necessary. The cables and the 11kV feeder cables mentioned above were manufactured by W. T. Glover and Co., Ltd., and installed by London Transport.

The substation control cabling is carried in sheet steel trunking and marshalling cabinets, at one end of each line of d.c. truck switchgear, facilitate the installation, checking and testing of the control and indicating circuits in the substation. The final control marshalling cabinet is situated on the upper floor next to the rectifier relay board. Without these marshalling arrangements, the changeover of the traction current feeds from the old substation to the new would be virtually impossible during the few night hours when the station can be shut down.

As the substation serves three separate Underground lines, the changeover of the track feeders are being done one at a time, and only at weekends, when longer track possessions are possible: the four sections of the District Line have been changed over and are now fed from the new substation.

All the new equipment is temporarily remote-controlled from the old substation by a centralised control panel, which was designed and produced by London Transport staff. In the near future permanent control panels will be installed in a control room on the upper floor of the new building. These panels will also provide remote-control for the rotary converter substation at Lambeth, which has hitherto been controlled from the old Charing Cross substation. This work is being carried out by London Transport staff. Space is available for similar equipment for the remote-control of four or five other substations.

It is expected that the last of the traction feeds will be connected to the new substation early in the New Year, but completion of the connection of the auxiliary supplies will not be possible before next spring.

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## Demolition by Controlled Blasting

Demolition of some heavy reinforced concrete has recently been carried out in Central London by controlled blasting. Many examples can be given of successful blasting in confined areas, without damage to the surroundings, but the method has not been used before, we understand, in the centre of London. It is considered, however, that the skilful application of explosives to demolition work of this nature will be more important in the future. Reinforced concrete buildings and structures are relatively new, and comparatively few have had to be demolished up to the present; but they are now widespread, and from the point of view of demolition, they are singularly awkward, and the controlled explosives technique offers considerable advantage.

A large office block is at present under construction next to the B.B.C. building in Portland Place. Existing structures, including air raid shelters, had to be demolished over the extensive basement area of this site, and controlled blasting was used successfully. The most difficult job was the demolition of a "skin" wall of heavily reinforced concrete.

A wartime shelter of massive reinforced concrete had been strengthened by adding this "skin" to its outer face. The wall was 32ft high and 62ft long, and was carried at its base by a reinforced concrete beam and four columns, each 2ft square and 18ft high. The wall was 2ft thick and was reinforced on both faces with ¾in bars spaced 6in apart in both directions. The site was too constricted, and the wall too strong, to attempt demolition in one go, but successful demolition in small stages was eventually achieved, without damage to the surroundings or to the interior of the structure from which the wall was removed.

The height above ground (i.e. basement level) at which the work had to be done was one of the principal difficulties. A scaffolding tower was first used, but this method was quickly abandoned because of the time lost in rigging staging every 3ft to provide a platform for the drillers. This staging had to be removed before each blast. The tower was too unwieldy for the four men in the blasting team to move without considerable outside assistance, and subsequently suffered damage from falling debris. A cradle with running rail was therefore rigged from the top of the wall, and by "Rawlbolting" this cradle to the face drilling time was reduced by 50 per cent. Only two drillers could work from the cradle at a time, the third driller being employed on other blasting jobs at the same site.

The first operation was to break and remove the reinforced concrete beam in the bottom of the wall. This was achieved with a 15in horizontal drilling pattern 12in above the base of the beam. Holes were inclined downwards 10 deg. from the horizontal, the depth of the hole being critical to 1in limits for successful demolition on blasting. This process was repeated with other rows 12in higher until the beam depth had been covered. High explosive charges with electric detonators were fired in successive groups until the beam was shattered. The steel reinforcement was then burned away and the shattered portion dropped. The reinforced concrete column was then blasted at the base, the exposed steelwork burned and the column felled, and later shattered with high explosives whilst on the ground.

After removing the beam the wall was then drilled with the same pattern as that employed for the beam, but with larger spacing. The shot holes in this phase of the operation were slightly overcharged in relation to the mass being removed, to ensure a good clearance of debris. It was found that approximately 1 cubic yard could be removed at each blast, but the noise was somewhat high on occasions when the energy of a particular charge would be dissipated to atmosphere. Drilling was carried out during the morning and afternoons, with blasting taking place during the midday break and after "knocking-off time," so that no time was lost by other labour on the site.

Screening was accomplished by a blanket of corrugated sheets wired to a 6in mesh of ¼in diameter wire net, suspended from the top of the wall. A normal blasting session would give vertical progress of 8ft to 10ft over an 8ft wide strip. Vertical movement involved less effort than horizontal movement. Maximum "throw-out" of debris at floor level was found to be 20ft, which was acceptable bearing in mind that a good deal of the blasting was carried out almost 50ft above floor level. The top 4ft was left as a working platform and was finally demolished when all the equipment used for blasting the face had been removed. It was necessary to "chase" this top section to a depth of 2in to reveal the reinforcing bars, which were then cut before blasting. These bars were the ones passing horizontally into the top of the existing structure. The chases were cut with a rock drill. By swinging the drill like a pendulum alongside a plank used as a guide a clean chase was achieved in a shorter time than would have been possible with a pneumatic hammer.

Due to the wide variety of reinforcing encountered on this particular site, it is difficult to give an exact schedule of progress, but in the main a four-man explosives team has fragmented between 20 and 30 cubic yards of heavily reinforced concrete daily. The main contractor on the site is F. G. Minter, Ltd. The demolition and earthmoving contractor is Goodman Price, Ltd., and the specialist explosives work described here has been done by Messrs. Swinnerton and Miller, of Wolverhampton.

# Railway Modernisation Problems

*In his presidential address before the Institution of Locomotive Engineers on Wednesday, September 25, Mr. E. S. Cox dealt with the approach to modernisation on British Railways and with some major problems involved. He first gave general impressions of development over the past fifty years and the transition from steam to diesel traction, and said that despite the magnificent achievements of steam in the past, it had to be admitted that the possibility of further major development in steam traction had become exhausted. Abstracts from the latter part of Mr. Cox's address, which dealt with some of the problems of railway modernisation, are given below.*

AS we move in closer to the events of to-day and tomorrow, to the carrying out of the Modernisation Plan of 1954 itself, it becomes difficult to convey in a limited number of words the sense and feeling of being involved in this enterprise. It would be fascinating to explore the probabilities of new rolling stock development, but for obvious reasons it is only proper to await official disclosure at the appropriate time. I propose, therefore, to attempt a word picture of four of the problems of the railway modernisation which are never finally solved. All inherited from the past, they accompany us in our daily work, and however well we think we have dealt with them at any particular time, they continually reappear in the changed circumstances of the next phase. They are selection of motive power types, best relation of power to weight, the interrelation of vehicle and track, and the endless contest of standardisation with diversification.

### Selection of Motive Power

The dream of all operating and maintenance men is to have only one motive power type, using a single set of interchangeable components, capable of all duties and of running everywhere. To the best of my knowledge this ideal has never been attained on any substantial railway anywhere in the world. Diesel and electric traction at once introduces the broad divisions of locomotive-hauled and multiple-unit trains. Over a wide field the latter cost less for a given power, and the power-to-weight ratio is always correct, whatever the length of the train. Locomotives on the other hand, are the only currently practicable solution for freight, and since not all freight duties can be arranged on a round-the-clock basis, some locomotives must fill in part of their time at least on passenger duties, if their high first cost is to be liquidated by high utilisation. No general pronouncement is possible, and no short cut available to working out the best relation between the two, area by area. Nevertheless, decision must be arrived at year by year to enable the engineers to draw up their building programmes.

Some easing of this often complex choice would result if locomotives could propel as well as haul trains of passenger stock so as to approach the operating facility of the multiple-unit train. Propulsion of a few vehicles at speeds up to 60 m.p.h. is common enough, but with very few exceptions there is visible reluctance throughout the world to propel more than two or three vehicles at speeds up to 90 m.p.h. The difficulty here is not to demonstrate safe working when all is well, but rather to be assured that no specially unfavourable effects would result from a head end derailment.

Turning to the locomotive itself, much flows from the consideration that while diesel and electric traction offers so much that is different from steam, it has these points in common : (*a*) that a big locomotive costs more than a little one, (*b*) that two little ones together cost more than one big one of equal total power, and (*c*) that our inheritance from the earlier individual railways still calls for more than one axle loading to cover total route availability. The first of the above considerations may make uneconomic any solution which seeks to limit variety by providing only single locomotives which will do the heaviest work. Under British conditions intensive work can be found for units of far less than maximum power, so that, traffic-wise, several steps in locomotive power can be justified. The second point that two little locomotives cost more than one big one, like for like, limits the justification for the opposite policy that only moderate powered locomotives need be chosen, which by tandem working can, in combination, meet all larger power needs. There is a tremendous field for tandem working, but wherever high head end power is demanded with a sufficiently high degree of continuous utilisation, there is a field for the economic use of powerful single units. Here, again, the temptation must be resisted of making large statements of principle not related to area traffic conditions. The need to do so is lessened by the fact that, unlike steam, wheel rim efficiencies of diesel and electric locomotives do remain practically constant over the useful power range.

In the main line diesel field, two other major choices lie between electric and hydraulic transmissions on the one hand, and between medium speed and high speed diesel engines on the other. I will not make any further contribution to the over-documented question of transmissions, except to say that choice does not itself affect type of locomotive profoundly and we have on order locomotives of identical size, engine type and general design, differing only in type of transmission and in axle weight. The feeling not only here, but in Europe generally, is that in spite of all that has been written, the relative merits of electric and hydraulic transmissions have yet to be established.

The type of diesel engine, medium or high speed, has a much more direct effect upon type of locomotive. In a given power category the difference between the heaviest and the lightest engine can mean 50 per cent increase in locomotive weight due to multiplication of axles to meet civil engineering considerations. The haulage of 40 or 50 tons of excess dead weight is in several senses no light matter, so that there is a predisposition towards lightweight engines and transmissions if they will give good service. There is also, however, an even greater predisposition towards reliability and durability and most of the new lightweight power units have yet to win their spurs against their older and heavier competitors.

### Best Relation of Power to Weight

It is a platitude to say that power must be sufficient to perform the required duty and that weight should be as low as possible. The ratio of power to weight tells us something, of course, of the character of a locomotive-hauled or multiple-unit train, but it can be a deceptive figure for use in generalisations, divorced from the particular duty involved. With the possibility of multiplication of units, whether locomotives or car sets, diesel or electric, under the control of a single crew, the problem of providing enough power has receded. The current emphasis is thus much more on weight than on power.

Light weight as a policy centres largely round how much one is prepared to pay for it, not only as new construction, but in repairs throughout the vehicle's life. It depends in another sense upon what are considered to be the minimum needs of safety and amenity. Given a finally chosen form of construction, weight per passenger seat reflects the relative commercial value of packing the customers in, or of buying goodwill with greater space for the individual.

To-day we are again facing the threat of increased weight. Engineers will do well if by further refinement in structural design, and selection of materials they can keep ahead of the effects of introducing air conditioning, better heating and lighting, and more effective sound insulation. Other amenities such as increased leg room, reclining seats and improved toilet facilities, increase the weight which has to hauled per fare-paying passenger.

I do not think that anyone is satisfied that the best relationship between all of the conflicting factors affecting rolling stock weight has yet been attained. The constant shifting of viewpoint in successive periods not only here, but abroad, shows how uneasy is the balance, and it is clear that a great deal more integrated thinking on this subject is going to be required, particularly on the economic and commercial sides.

The locomotive is also, of course, part of the whole train which the installed power must move. The essential role of adhesion requires no elaboration, and highest adhesive weight with least total weight demands the total elimination of carrying wheels. Some difficult relationships between weight of available power equipments, and civil engineers' permitted axle loads have required even now that some of our main line diesels should carry idle wheels. In these early days of development, 2000 engine horsepower will be seen in locomotive weights as different as 140 tons, 110 tons and 80 tons. There is no question which of these is preferable for the mechanics of a railway, but the elements of first and maintenance costs and of reliability have a part to play, so that the conclusion is not yet a foregone one, as I have already indicated.

A big field of investigation attends the question as to how light a locomotive can be for a given power and tractive effort, and this in turn reverts to the characteristics of different traction systems, and to the nature of wheel to rail adhesion. The latter, at any rate, still holds mysteries of the deepest kind, which are the subject of current research.

### Vehicle and Track

Although I would not necessarily subscribe to it, a case could be argued that the riding quality of bogie rolling stock in this country has not improved decisively over the past several decades. Unfortunately, until recently, this was not a recordable function, so that we have only memory and personal experiences to rely upon in supporting or denying such an assertion. Nevertheless, the problem of interaction between vehicle and track, in order that the destructive effect of each upon the other may be minimised, and the twin problem of passenger riding comfort, are at the very centre of to-day's phase of modernisation. It is unlikely that finality can ever be reached because of the interplay of contradictory requirements and the increasing demand for high speed and more amenity.

Developments through the years have ensured a remarkably high standard of safety, but lack of exact knowledge and scientific understanding have impeded progress in other directions. To-day, the matter is fully active in a dozen countries. The Office of Research and Experiments of the International Union of Railways has several major investigations in hand. On British Railways, comfort meters, load measuring rail baseplates, and a whole research effort closely in touch with O.R.E. are preparing to probe and measure this vast subject. So from a hundred years of partial success without really knowing why, we are to-day in a second stage of asking questions and getting answers. In a very near tomorrow, we are confident of applying the right answers in a really effective way.

This work is already changing the emphasis for passenger carriage design. Now it is less a matter of adding to the hundreds of different kinds of bogie arrangements evolved through the years, than of concentrating upon suspension characteristics and, above all, of reducing or eliminating initial clearances, and of reducing wear to vanishing point at least between general repairs.

Few, if any, bogie designs give a bad ride when new. If they do it is usually due to some obvious and easily remedied defect. I should not like to count the presentation of new stock I have attended where initial congratulations upon good riding were the order of the day. A year, several years after, all is silence, and the new design has joined the over-populated limbo of indifferent performers.

To prevent or mitigate the effects of wear is therefore paramount, although less easy than

appears at first sight. New materials, elimination of metallic contact, reduction in initial clearance are achieving this in all countries, and here there are prototype bogies running about which are maintaining good riding well into the 100,000 miles. Soon there will be many more.

Far from welcoming the extension of the bogie from carriages to locomotives in the new forms of motive power, civil engineers are showing no little apprehension as to what the ultimate effect may be upon the track. It has been explained earlier why the mechanical engineer seeks to eliminate all carrying wheels. In BB or CC type locomotives, heavy loading driven wheels act upon rail joints without any preparatory "lead in," such as was afforded by the leading trucks of steam locomotives. For this reason, we are now limited to 20 tons maximum axle load, although for steam up to 22 tons was acceptable on many main lines. Such vertical loads may also be gravely accentuated if a considerable proportion of this leading weight is unsprung. Added to this is the factor that change in motive power almost always brings increased frequency of train service, and in the outcome there may arrive a concentration of circumstances inimical to track maintenance and life. For the mechanical engineer less permissible axle load means more wheels and correspondingly higher cost per locomotive of given power. Less proportion of unsprung weight may demand fully suspended, as against nose-suspended traction motors, again adding a burden of first and repair costs to the locomotive.

This subject of the form of motor suspension has been argued *ad nauseam* on theoretical grounds. What is urgently needed now is a pronouncement based upon actual measurement of the overall effect upon the permanent way of the various combinations of sprung and unsprung weight which modern design makes possible.

Much more recently another problem for the non-steam locomotive has reared its head, namely, the relation between vertical axle load and wheel diameter. It is not difficult to visualise that a small wheel will make a smaller area of contact on the railhead under a given vertical load than will a large one of the same material, and if the load was increased unduly it could induce stresses in the railhead sufficient to result in flaws after a sufficient number of repetitions. These considerations are fundamental, for example, in roller bearing design, but nobody in the whole wide world seems to know just where the line should be drawn for railway rolling stock.

We have reached a temporary agreement with the civil engineers not greatly to exceed a ratio of five for the relation between vertical axle load in tons, and wheel diameter in feet. The larger wheel which such a ratio demands on the more powerful locomotives is very restrictive to design, and a great deal more experience and investigation are needed before we can be sure of having arrived at the best value.

Rather surprisingly, little work has been done abroad on these various vertical interactions between rolling stock and rails, and it will fall to British Railways to pioneer in exploring this subject on which there are many forcefully held opinions, but not many real facts.

### Standardisation and Diversification

I have left until the last one of the toughest problems which faces to-day's modernisation, as indeed it has faced all stages of our long history of development hitherto. This is how to obtain the desired degree of standardisation against a background of prolific and expanding technical diversity. Although there is much shying at the word "standardisation," I do not think that any engineer is unaware of its purpose, or is at variance with its objectives. Heat is only generated when the standard to be adopted is somebody else's and not one's own, or where the extent of the standardisation seems to be unreasonable. The majority of railway mechanical engineers, at any rate, have demonstrably sought some measure of standardisation in their rolling stock, but with whatever intentions they started, no large railway has ever brought quite to fulfilment a consistent long-term system. Perhaps the best example which comes to mind from the past, is the locomotive policy of the old Great Western Railway between the years 1903 and 1947, but the story was otherwise on the same company as regards carriage stock. Far more generally, standards have been established and have produced savings great or small, perishing under the onslaught of some new development or some new mind, and leaving the backwash of one more set of spares to be stocked during the remaining life of the rolling stock.

The impact of this question is sharpened to-day by the new forms of motive power and the opportunity which their widespread introduction gives to do the right thing if this can clearly be discerned. Unlike the days of steam, industry now has a prime interest in our solution, as sole providers of the power equipments.

In sketching in the outline of what requires to be solved, I naturally cannot attempt to indicate the lines which the Commission will eventually follow, which will require and will be given the most profound attention. Nevertheless, consider the following.

The catalogue published by the British Internal Combustion Engine Manufacturers' Association shows that eighty-eight different diesel engines of nine different makes are available for rail traction above 300 h.p. and this does not include two other important ranges of engines now in production in this country. Already developments are heard of which will increase the numbers both in the form of new home products and of foreign engines capable of being built here under licence. While trial of any of these engines may identify and eliminate the weaker brethren so far as particular purposes are concerned, the experience and integrity of the many well-known firms make it likely that the majority of these variations are capable of satisfactory service.

Consider six makes of electrical transmission and control gear and five forms of hydraulic transmission already in use here, together with at least one more still below the horizon. Think of these in their different sizes, each capable of combining with a variety of the engines mentioned above. Consider the possible variety of modern bogie designs, and consider finally that to place any of the foregoing in order of merit so far as sustained performance is concerned may require two to three years. To assess real repair costs requires completion of cycles of maintenance which may extend over seven to ten years.

Merely to state such facts indicates the magnitude of the problem of selection, and the challenge to constructive thinking is intense. For example, is it wiser to seek only limitation in variety or to pursue active standardisation? If we look abroad to those who have preceded us in large-scale dieselisation, we find opposing views. In Europe, the International Union of Railways is selecting from a huge number of available variations a limited number of types having standardised features. This is being done under the auspices of its Office of Research and Experiment, and all must watch the progress of this development with interest. In America, an industrial giant, having largely imposed its own conceptions upon the railways in the first place, has by gradual elimination of competitors, produced a most effective nation-wide standardisation.

For British Railways, if we seek only limitation, must we confine ourselves to types already tried or proved in this country, which will freeze out a large number of others, or if we select from the promising but untried newcomers, what is to be our yardstick? If, on the other hand, we pursue standardisation, how far do we go? Frequently renewable details such as tyres, brake blocks, electrical fuses, &c., of course. Wheels, axles, axleboxes and cab layouts, probably. Interchangeability of complete engines, bogies and traction motors, a big question mark. Standardisation of the complete locomotive in a series of steps in power and weight is a matter requiring the most careful thought.

Having chosen to the best of our knowledge and ability, there is then the overriding point of how to accommodate the new thoughts on design, the new level of efficiency and performance which can confidently be expected in the coming years, and which are perfectly capable of upsetting violently all our preconceived ideas. I have dealt here with diesel traction in which the problem is most acute, but a number of the elements described apply also to electric traction.

So variety there must be and change is inescapable, but these virile and unruly manifestations must in some manner be tamed and controlled to our best interests. One thing seems clear. Both limitation in variety and standardisation will be best served in proportion as all new developments are capable of being substituted for obsolescent units in existing locomotives and vehicles within their thirty years or so of total life. In such a manner the dead wood of obsolescence at any one time could be largely cut away. Self-obvious as this may well appear, it represents a level of continuous and long-term integration of the efforts of all concerned to a degree well beyond anything hitherto achieved in this country.

## Commercial Vehicle Development

The range of engines available in Bedford commercial vehicles, and discussed on page 266, February 15 last, has now been rationalised by the introduction of a four-cylinder version of the six-cylinder diesel engine, which now takes the place of the Perkins "P.4" on vehicles from 25 cwt to 3 tons. The 200 cubic inch and 300 cubic inch engines have a large number of parts in common and the same governed speed of 2600 r.p.m., corresponding to a net power two-thirds that of the 89 h.p. engine. The gross power of the smaller unit is 64 h.p. at 2800 r.p.m. and it weighs 785 lb.

Vauxhall Motors Ltd. has now commenced to manufacture its own two-speed axle, providing a secondary reduction at the driver's selection. In the case of the 5·8 ratio 17,000 lb axle on vehicles of 4 to 7 tons, it provides an alternative 7·9 ratio, and for 8 and 10-ton tractors it is built with ratios of 6·4/8·7. Except that it features a hypoid primary reduction, it resembles the previous proprietary component, but is 45 lb lighter, being 110 lb heavier than the single-speed axle. Vacuum operation is standard, using a dual line system, and control remains by a push-pull knob on the gear lever.

Other changes in the Bedford range are that the 10/12 cwt models now have smaller wheels and smaller tyres, 5·90×15 instead of 6·00×16; the ply rating has been raised from 4 to 6, the gross vehicle weight remaining at 3700 lb. The heavy-duty option (4100 lb) is again six-ply, but larger section, 6·40×15 instead of 6·00×16. A change affecting all vehicles other than the van is that moulded brake linings are now standard. Tubeless tyres have for some months been optional on vehicles other than 35 cwt and 7-ton trucks.

## Open Days at Lloyds (Burton), Ltd.

Open house was held on Thursday and Friday last week at the Wellington works of Lloyds (Burton), Ltd., Burton-on-Trent. The occasion marked the arrangement between Lloyds and the American Brake Shoe Company for the production of certain heat and wear-resistant alloys, and of accurate ferrous castings intended mainly for the aircraft and tyre-making industries. Visitors saw an exhibition of castings made by their hosts, together with examples of machinery and equipment incorporating such castings. Among the specimens displayed was a 19½-ton cast steel frame for the Ruston Bucyrus "150 R.B." excavator. Serving as a rotary chassis, this frame is supplied with a machined finish. Another large exhibit was the cast steel half-casing of a carbon dioxide blower. This was made for C. A. Parsons and Co., Ltd. to use in the circulating system of a nuclear power station reactor. In the roughly machined form, as delivered, the weight of this casting was said to be 16¾ tons. Examples of accurate casting for the tyre industry were shown, including a high-duty iron mould for the Dunlop 26·5×25 "Earth Mover" tyre.

Visitors were conducted round the works which are reported to have been considerably expanded for the production of castings of up to 20 tons unit weight in high-duty and spheroidal graphite irons and carbon and alloy steels. The recent reorganisation of the production control system is said to have led to a satisfactory improvement in efficiency and output.

# LETTERS AND LITERATURE

## Letter to the Editor

*(We do not hold ourselves responsible for the opinions of our correspondents)*

### INSTITUTION MEETINGS

SIR,—Your leader "Institution Meetings," in the issue of September 27, deals with a Great Truth. Too many papers are read by too many people in too many places and, gradually, some people are beginning to realise it.

Of course, delegates do not *have* to attend conferences; scientists and others do not have to read all the papers that are written, and authors do not even have to write papers. But the poor librarian does have to note and index every paper in his own particular field in case it is asked for, so that it is he who is the main sufferer in the long run. At the beginning of this year I read a paper to the aeronautical group of Aslib, in which I suggested that we are in danger of being drowned in a tidal wave of scientific papers and the Archbishop of Canterbury said much the same thing. In its monthly bulletin of *Scientific Documentation and Terminology* for July 15, U.N.E.S.C.O. comments on and cites the case of the abandonment of a congress by the Federation Européene de la Corrosion because there were insufficient prospective "congressees." This prompted the Association française pour l'étude des Eaux to ask in its *Bulletin d'Information* (which U.N.E.S.C.O. quotes) whether the epidemic of congressitis was overwhelming the scientific world.

So many of the papers which appear are repetition and stews concocted from previous papers. Time and again the same authors write on the same subjects. Can it be that prestige hunting is the driving force? Are all these papers really written in the desire to share knowledge with one's fellows? If it is, then the frustration felt by many of the authors when they encounter trade or national security must be almost killing. It is a pity, perhaps, that it is not quite.

F. H. SMITH

Walton-on-Thames,
September 27, 1957.

## Book Reviews

**A Scientific Sampler. By R. STEVENS, H. F. HAMACHER and A. A. SMITH. Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2. Price 45s.**

THE curious title given to this book may well cause the reader to turn to a dictionary, and there (if it be the Short Oxford English one) he will find a "Sampler" described, in at any rate its masculine form, as "an example to be imitated." If this definition be accepted opinion may well differ whether this ambitious objective has been attained.

The authors describe themselves as members of the large staff of 400 "scientists and engineers" engaged in the production of an American research bulletin which has existed for many years past; one of them is apparently its present editor and the others two of its past-editors. The firm named as responsible for the whole enterprise is Arthur D. Little Inc.

Much is said concerning the general relationship of scientists to discovery, as well as of engineers to invention, and the interesting question is mooted whether it often happens that such links arise not so much by intention as by accident. The authors claim that "accidental" advances occur usually to those who, in virtue of their training or ways of thought, are most likely to be quick to profit by them. Moreover, scientific research is commonly part of an established plan of experimentation designed, as the authors put it, to "compel nature to yield definite answers to questions propounded in advance." Nevertheless, inventions not infrequently arise through what is sometimes called "serendipity," a word first used, we are told, by Horace Walpole in a "fairy story" about Three Princes in Serendip (now Ceylon), who had the gift of making most valuable discoveries whilst diligently looking for something entirely different! Since an industrial population is the one likely to put most effort into such inquiries, it is the more apt to reap benefit from "serendipity." May not, indeed, our own British Association for the Advancement of Science (the "B.A.") have gleaned in that same wide field? Certainly, it has grown steadily in popularity, whilst in the U.S. a society having the same general aim has been able to attain astonishing size, having passed in its tale of members and associates a number exceeding 1,000,000.

One of the important subjects discussed, and one to whose rapid progress the authors pay fitting tribute, is the use of electrical methods in computation. By this labour is saved, and the speed of operation made amazingly high. The authors tell us that in the U.S. a dozen firms now offer electrical computers of a variety of sizes for scientific and industrial tasks (and maybe sporting events, too!); indeed, there are reported to be so many of such installations in that country as to make the computer field possibly the fastest growing segment of the whole electronics industry. Even civil aviation is, it is claimed, made the safer for its many passengers, as well as the still larger number of citizens who happen to live near the larger air fields; during flight the plane's position can be continuously reported by radar to an electric computer with the result that the landing of planes when weather conditions are difficult can be made safer and much more rapid.

In the section dealing with nuclear power, an account is given of the repair after breakdown (in December, 1952) of a nuclear reactor in Canada, of which a part was found to be damaged beyond repair and needed replacement, but the station as a whole was reported as restored to full operation in little over a year, and this, the authors state, was effected without accident or any dangerous exposure of the personnel concerned. Of all recent inventions the "atomic clock" is surely among the most curious; in this a radioactive isotope of carbon produced by the impact of cosmic rays upon the earth's upper layers in its atmosphere gradually gets absorbed by plants and animal tissues, with the useful result that the length of time since contact was made (if not much more than a few thousand years ago) can be estimated by measuring the amount of radioactivity that remains in the specimen selected. The authors consider that the period of time thus measurable runs to about 16,000 years. This kind of clock can be valuable to geologists, and perhaps even more so to archaeologists.

Many will read with interest the section dealing with operational research. Experience gained in World War II showed how great an advantage could arise by bringing Service chiefs into really close personal relationship with such civilian staff as scientific research directors. This may seem obvious enough, but it was at one time rare for any high-level meeting of a Service group to be attended in person by its own research directors; it took years of experience to show the disadvantage of the former feudal stratification, but the change led to much happier results. Those liaison officers having the task of administering this new business-like method of co-operation are among those described as engaged on operational research.

The periodical issue of scientific abstracts is a not unusual feature in the activities of professional institutions of various kinds, but a compilation ranging over thirty years and now surveyed in a single volume, as in this *Scientific Sampler*, should be useful for quick reference into past research.

**Instrumentation in Testing Aircraft, Vol. V. By C. N. JAQUES. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 45s.**

THIS work is the fifth of a series of monographs published under the authority of the Royal Aeronautical Society. As its title suggests, it is not primarily concerned with ordinary flight instruments, but rather with the special devices used in flight testing. Logically, it is divided into three parts, entitled "Basic Principles," "Measurement of Physical Quantities," and "Data Transmission and Recording." The first part is fairly short and consists of a treatment of dynamic measurements and measuring elements, the latter chapter being confined to bridge circuits and springs. The second part discusses the methods used to measure all the quantities involved in flight test work, describing the appropriate instruments in somewhat variable detail and indicating their limitations, errors and corrections. The third part considers the principles of some data transmission devices and describes various recording equipments. The author has deliberately confined himself to British equipment and, as one would expect, many of the devices described originated at R.A.E., where he was formerly head of the instrumentation department.

Inevitably, a book about a rapidly developing subject cannot include the latest developments. For example, the devices illustrated in the chapter on "Airspeed and Altitude" are very subsonic and, although reference is made to modern developments, the latest paper on this subject quoted in the bibliography is dated 1949. Whilst it is fairly easy to find omissions (e.g. there is no mention of the vortex-tube air temperature thermometer) the author can justifiably stand by his assertion that he is concerned with proven

ways of measuring a particular physical quantity. However, to return to the bibliography, no paper later than 1953 is quoted, which hardly agrees with the statement that "... the references are confined to the latest on the subject. . . ." Whilst the description of individual instruments is very good, indeed in some cases almost too detailed, there is a misleading statement in Chapter 12 about the effect of prolonged turns on the indication of a pitch-and-roll indicator. This can be read as perpetuating an ancient fallacy. The book is well produced and the diagrams are generally excellent, although a few of the reproductions of photographs are rather poor. The overall impression is of high quality, careful writing and attention to fundamentals.

**An Introduction to Automatic Digital Computers.** By R. K. LIVESLEY. Cambridge University Press, Bentley House, 200, Euston Road, London, N.W.1. Price 8s. 6d.

THIS little book of about fifty pages is based on a series of lectures first given at Manchester. It is clearly and simply written as an introduction to the subject of automatic digital computers and is in the main intended for engineers and others concerned with tedious calculations. It has carefully avoided all but the simplest mathematics and uses examples that all can follow. It has equally avoided describing any specific machine. Though it indicates the effect of different storage techniques on the time taken to get access to stored data, it does not delve into the mysteries of computer structure. It does explain the steps by which particular problems are put into a generalised form and then broken down into a series of simple arithmetic operations, and then these operations performed automatically under control of a programme.

It rightly and illuminatingly likens a programme to a game of snakes and ladders, with its repeated loops. Valuable emphasis is placed on the importance of building up a library of generalised programmes. The labour of building programmes is expended once for a lifetime with innumerable different subsequent uses, so that the proper assembly of them initially and checking that they are correct under all circumstances is shown to be worth the labour. The final chapter gives details of a number of straightforward engineering problems solved on computers, tending to show that the use of computers is not beyond the reach of most engineers for routine work. Four photographic plates are provided covering the Manchester machine in 1948, the Deuce in 1955, the face of a cathode ray tube, a magnetic core store, a magnetic drum, Teletype tape and Hollerith cards. These all receive but scant comment in the text so that the significance of what they show is largely lost on the newcomer in this field.

Throughout, the book assumes that engineers and physicists are those most concerned with computers, but the fact remains that there are a growing number of persons working in the fields of statistics, insurance, or accountancy for purposes of management or sales or production, who are equally anxious to gain the sort of basic knowledge which this introduction to the subject provides, and an example or two drawn from such fields would have helped.

We have often been asked to recommend a book on computers that is not too complicated, but which gives a fair picture of what it is all about, so that the inquirer can judge whether his problems are suitable for machine solution. This book seems to us to have achieved that happy mean and is particularly recommended.

**Basic Reinforced Concrete Design: Elastic and Creep.** Second edition. By G. E. LARGE. The Ronald Press Company, 15, East 26th Street, New York, 10, N.Y. Price 7.00 dollars.

PROFESSOR LARGE has written a book primarily for students, but one which many practising engineers will find of great value as a refresher course. He approaches the subject from first principles, and when empirical methods are required, refers to the 1956 American Concrete Institute Code. The making of concrete is briefly dealt with in the first chapter and a clear account given of the fundamental stress-strain characteristics of concrete and various kinds of reinforcement. Chapters 2–4 explain the assumptions made and resulting design theory for beams and columns. Many illustrative examples are given. Chapter 5 deals with continuity of beams and simple frames, as elastic systems, using moment distribution and slope deflection methods, which are an excellent introduction, but could have been followed with great advantage by the more comprehensive approach of general elastic equations. In chapters 6–10 the practical requirements affecting the design of building floors, flat slab systems, together with design formulæ, are discussed and many illustrative examples given. Creep and its influence on deflection and column stresses is well discussed in chapter 10. Shrinkage and temperature effects are dealt with in chapter 11. This subject, which is often all too briefly covered, is well considered in its relation to typical design problems. Chapter 12 introduces ultimate strength design in regard to beam sections and is mainly concerned with Whitney's method. Chapter 13 briefly introduces the design of prestressed concrete beams. A useful Appendix is included, containing beam and column charts, moment distribution carry-over factors, bending moment factors for various live load distributions on floors, basic design information for retaining wall design, excerpts from the (British) First Report on Prestressed Concrete, and the A.C.I. Code, including Ultimate Strength criteria. This is a comprehensive textbook, very clearly presented and with theory abundantly applied in illustrative examples.

**Surveying: Elementary and Advanced.** By W. H. RAYNER and M. O. SCHMIDT. Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2. Price 63s.

**Surveying.** By C. B. BREED. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 44s.

BOTH of these volumes are new editions of American textbooks on surveying; in both cases, the subject matter has been brought up to date. The volume by Messrs. Rayner and Schmidt combines two earlier publications and is intended to give an integrated and inclusive study up to the advanced standard. It includes instruction on "special surveys" and it aims at giving a comprehensive understanding of a surveying project, and at teaching the subject in the context of "an indispensable element in the economical design and construction of civil engineering projects." Mr. Breed's textbook aims at covering the fundamentals in the limited time often allowed for surveying in a civil engineering course. Aerial surveying, and setting-out problems are included in the text. Both volumes refer to American practice in, for instance, a description of the United States system of public land surveying.

## Technical Reports

*An Impurity Analysis of Aluminum by Radioactivation and Scintillation Spectrometry.* By P. Iredale. Atomic Energy Research Establishment, Electronics Division paper A.E.R.E. EL/M 96. H.M. Stationery Office. Price 2s. 6d.—The use of a γ-ray spectrometer in the analysis of impurity in aluminium is described. Aluminium specimens were irradiated in a flux of thermal neutrons and certain impurities were identified by measuring the energy of the γ-rays (where produced) and the half-life. Thus, slight impurities were detected without chemical separation.

*The Determination of Aerodynamic Coefficients from Flutter Test Data.* W. G. Molyneux, B.Sc. A.R.C. Current Paper No. 347. H.M. Stationery Office. Price 2s.—A technique is described that enables the oscillatory aerodynamic coefficients for an aerofoil to be determined from data measured in flutter tests on the aerofoil. The method is attractive in that it dispenses with the excitation equipment that is usually required for oscillatory force measurements. Preliminary measurements have been made in a low-speed tunnel on two rigid rectangular wings, and the results show that the technique is worth developing.

*Bibliography on Shock Waves, Shock Tubes and Allied Topics.* By K. Dolder and R. Hide. Atomic Energy Research Establishment, General Physics Division paper A.E.R.E., G/R. 2055. H.M. Stationery Office. Price 13s.—The bibliography has been taken from a Harwell card index on the physical properties of hot gases. References are arranged under subject headings in chronological order. The sections on shock waves and shock tubes include most published work up to the end of 1955 and some more recent references. The N.P.L. and Princeton University bibliographies have been incorporated.

*Probleme der Luftfahrtforschung und des Fluglarms.* By W. Georgii, A. Meyer, and F. Rudorf. Schriftenreihe des Luftfahrtbeirats Beim Bundesminister für Verkehr, Heft 3. Kirschbaum Verlag, Bielefeld. Price DM.4.50.—On December 11, 1956, three lectures were given in Frankfurt/Main before the German Advisory Committee on Aeronautics, by Professors Georgii and Meyer, and Herr Fritz Rudorf, dealing respectively with "The glider as a measuring device in aeronautical research," "Legal aspects of aircraft noise," and "Structure and organisation of aeronautics research." These have now been issued by the Advisory Committee in the form of a booklet. German designers have made much use of gliders in the development of motorised and jet aircraft. Professor Georgii's report described the application of high altitude gliding to the investigation of (for instance) turbulence in stratospheric "jet streams." Professor Meyer's contribution discusses the legislative steps which appear to be called for by the great amount of noise emitted by modern aircraft. While one school of thought maintained that people would have to put up with aircraft noise as the price of technical advance, the opposing school, headed more recently by the Swiss jurist, Professor Oftinger, accused the first one of "technological hybris," declaring that human well-being was the only measure of true progress. Some compromise evidently would have to be found and endorsed in legislation. Wartime destruction and the subsequent restrictions put a stop to German aeronautical research for several years. Herr F. Rudorf discusses the reorganisation in this field since the repeal of the post-war prohibitions, and the outlook for the future.

## Books Received

*Telecommunications.* By W. Fraser. Macdonald and Co. (Publishers), Ltd., 16, Maddox Street, London, W.1. Price 65s.

*Applied Analysis.* By Cornelius Lanczos. Sir Isaac Pitman and Sons, Ltd., 39, Parker Street, London, W.C.2. Price 55s.

*The Rolling of Strip, Sheet and Plate.* By Eustace C. Larke. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 63s.

*Modern Publicity, 1957–1958.* Edited by Frank A. Mercer. The Studio Publications, Ltd., 66, Chandos Place, London, W.C.2. Price 42s.

*Metallurgical Reviews.* Vol. I, 1956. The Institute of Metals, 17, Belgrave Square, London, S.W.1. Price by annual subscription, 42s. 6d.

*Building Construction.* Second edition. By W. B. McKay. Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, London, W.1. Price 16s.

*Garcke's Manual of Electricity Supply.* Volume 54. 1956-57 Edition. Electrical Press, Ltd., 19-20, Noel Street, London, W.1. Price 77s. 6d.

*Symposium on Vacuum Technology.* Edited by Edmond S. Perry and John H. Durant. Symposium Publications Division, Pergamon Press, 4 and 5, Fitzroy Square, London, W.1. Price 90s.

# Aluminium Foil Rolling Mill

*Aluminium foil is in increasing demand both for the existing market and new applications and to meet industrial requirements Venesta, Ltd., planned a new foil rolling line at its factory at Silvertown. The new line, which can produce high quality foil 30in in width and consists of four two-high mills having a combined output of 3500 lb of foil per hour, has been completed and is now in production.*

THE expanding demand for aluminium foil of high quality created by the increase in the number of applications for this material caused Venesta, Ltd., to plan a new rolling mill. This was designed to serve three main purposes, namely, to satisfy the demand for increased output, to enable the company to produce foil having a width of 30in and to ensure a product having a high quality finish. The new mill line consists of four two-high foil rolling mills having a combined output of 3500 lb of foil per hour. Work commenced in April, 1956, and was completed by September, 1957, and on September 20 Sir Thomas Williamson performed the official opening ceremony and switched on the power to set the mills in motion. The equipment is housed in the foil factory which Venesta, Ltd., built in 1950 and which has an area of 300,000 square feet and contains rolling mills, both two- and four-high, machines for printing, coating, slitting, reeling and laminating, together with other ancillaries. Aluminium, tin and alloy foils are manufactured and the putting into commission of the new line has raised the annual output to 6500 tons.

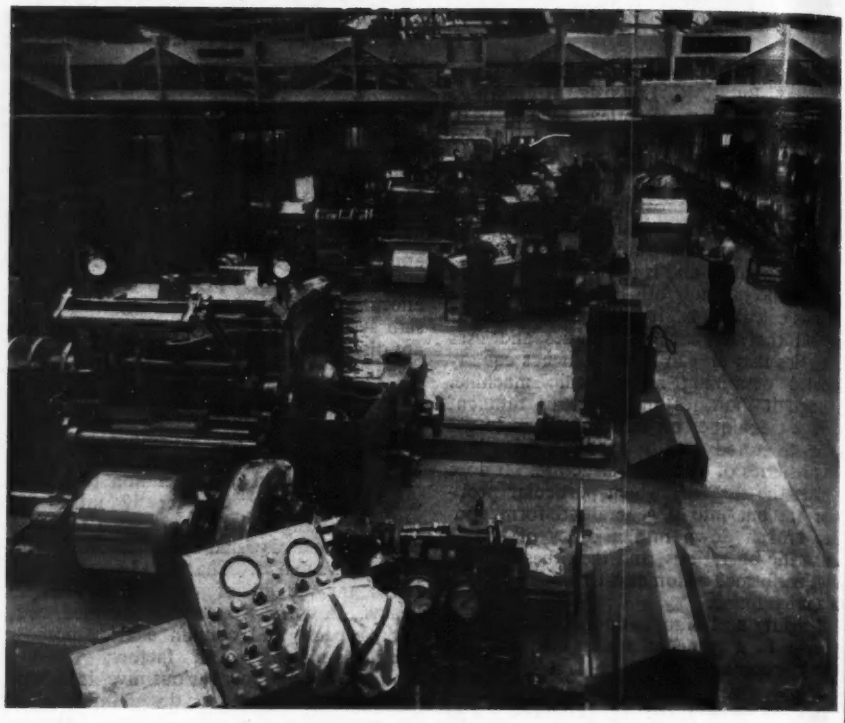
The four two-high mills seen in our illustrations have been supplied by W. H. A. Robertson and Co., Ltd., and Laurence, Scott and Electromotors, Ltd., has been responsible for the motors and switchgear. Each mill has two Firth-Brown alloy steel cambered rolls, mounted one above the other, having a diameter of 16in and a width of 41½in. The lower roll is supported by a 9in diameter hydraulic jack which closes the rolls and can exert a pressure of 1600 lb per square inch. When the pressure is released the lower roll drops and for renewal purposes the rolls are removed as a pair and the unit is broken down later. The rolls have 12in diameter journals carried in flood lubricated bearings and each mill has about 1300 gallons of oil in circulation.

For the main and coiler motors a.c. equipment is employed and the design of the installation is such that it combines the flexibility of the d.c. drive with the robustness and greater compactness of the a.c. unit. The main mills are each driven by a 200 h.p. 415V, three-phase, variable speed a.c. motor, having a speed range from 0 to 1400 r.p.m. A regulated speed rotor control governs the motor speed on the normal operating range but to overcome high torque when starting up provision is made to "squirrel-cage" the motors and use frequency converters to give a low-frequency, heavy current supply to the motor stators. When the motor attains a speed of about 35 r.p.m. a changeover is made to normal supply in a way which ensures that there is no snatch between 2½ c/s at starting and the normal 50 c/s. The arrangement also provides for a low "threading up" speed. The final drive to the mill rolls is through a set of turbine gears having a ratio of 2·6 to 1. The energy necessary to supply power to the coiling system is provided through a frequency multiplier.

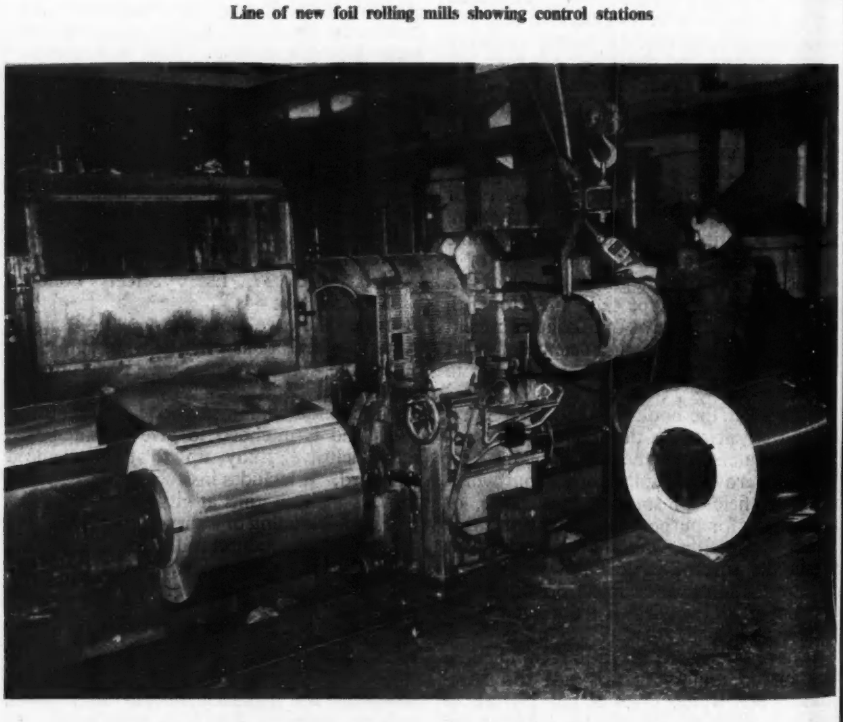
A system using pneumatic cylinders is employed for loading the foil to produce a predetermined constant tension which can be altered as desired, and it gives an over-riding speed control over the a.c. coiler motors which are primarily synchronised with the mill motors. However, under running conditions in which the rolling oil temperature, roll pressure, and both back and front tensions are stable, foil thickness is controlled by variation of the speed of the mill motor.

At the input and output side of each mill is a pair of chucks, which engage in the ends of the core of the aluminium coil, and form part of the double loading system. This reduces the time taken to load and off-load the coils and so increases the time available for rolling and the output of the mill. The unwinding and rewinding coilers are in duplicate and are traversed hydraulically to position the coil opposite the rolls and at the same time the track is covered by horizontal "Rolador" shutters. As soon as a coil is unwound or rewound the coiler is moved to bring a new coil or rewind core into position to enable rolling to be restarted, while the finished coil and core are removed and replacements made.

An essential part of the rolling operation is the oil installation and the oil itself which is specially blended to suit operating conditions. This oil is flooded on to the surface of the foil as it is being rolled and besides providing the essential lubrication for the rolling operation it serves to remove the heat generated during rolling. This heat alters the original camber of the rolls and it is the final camber, as controlled by the flow of lubricating oil, which determines the flatness of the foil. The oil is circulated by a pump at a rate of 75 gallons per minute; from the mill it proceeds to a dirty oil tank and then through "Autoclean" strainers to a clean oil tank, in an



**Line of new foil rolling mills showing control stations**



**Double loading system at the input side of mill, showing one coil being rolled while an empty core is being replaced by an unrolled coil**

underground compartment, ready for recirculation. Part of the oil, about 13 per cent, is passed through a Fuller's earth filtration system, supplied by the Paterson Engineering Company, Ltd., and consisting of "Stellar Filtraider" and "Stellar Filter" units. Although the mill is now in operation, the equipment dealing with the oil vapour generated at each unit has not yet been completed but it is intended to install, at an early date, an extraction system. This will consist of a fan of 8000 cubic feet per minute capacity which will exhaust the oil vapour from each mill through ducting and discharge same through a coke screen before passing out to atmosphere. Some oil will be recovered from the coke screen.

Foil is produced from coils of aluminium sheet of 0·45mm gauge which weigh about 1500 lb and are handled by two overhead travelling cranes having a working capacity of 3 tons and 2½ tons, respectively. High-speed rolling begins as soon as the correct tension has been established in the foil and the correct pressure at the hydraulically controlled rolls and also the correct roll profile as governed by the flow of lubricating and cooling oil. The reduction of the aluminium coiled stock to foil is carried out in four or more passes, of which, as at present arranged, three are carried out by the four two-high mills in the new line and the finishing passes on four-high mills sited elsewhere in the factory. At number one stand in the new line the reduction is from 0·45mm to 0·22mm at 500ft per minute and at number two stand, from 0·22mm to 0·10mm at a speed of 800ft per minute while number three and number four stands, at the same speed, the foil is reduced from 0·10mm to 0·05mm. Accurate control over the thickness is maintained at each pass by means of a beta gauge which has been developed by the company in conjunction with the Baldwin Instrument Company, Ltd. Each gauge houses an isotope, thallium being used in this instance, which produces a radioactive beam through which the foil passes on the output side of the mill. The radiation absorbed by the foil is in direct proportion to its thickness and a gauge on the operator's control panel indicates any small variation in thickness.

A further reduction in thickness is effected, in a four-high mill, from 0·05mm to 0·02mm and then, for the fifth pass, two rolls are wound on to a single coil in a doubling operation. The double thickness of foil is then passed through another four-high mill where the thickness of each is reduced from 0·02mm to 0·009mm and down to 0·005mm for condenser foil. After the fifth pass there is a splitting operation to separate the two sheets.

When attending the opening ceremony of the new mill line the opportunity was taken to make a tour of the other sections of the mill. Semi-continuous ovens and pit ovens are available for annealing the foil which has become work hardened and for removing all traces of the rolling lubricant to ensure that the foil is sterile. There is a battery of machines for coating the foil to protect it against corrosion and abrasion, to prime the surface for printing and to lubricate it. Designs in up to four colours can be printed by the aniline process; for particular packing requirements and where extra strength is required, the foil can be laminated, the backing material being paper or parchment, using water-based gums, solvent-based adhesives or molten adhesives. The foil can also be embossed and the finished foil is delivered either as cut sheets or in the form of reels.

# 4500 h.p. Electric Winder at Mosley Common Colliery

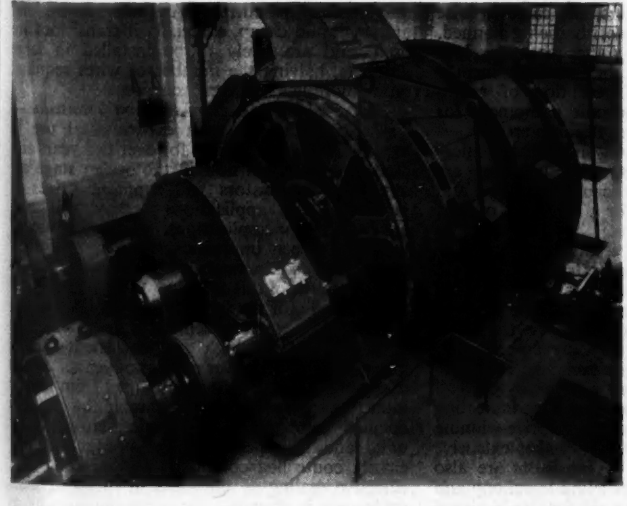
MOSLEY COMMON, one of the older collieries in the South Lancashire coalfield, is in the group of pits which, immediately before nationalisation, was owned by Manchester Collieries, Ltd. It had five shafts, all equipped with steam winding engines with cages for the coal tubs. Some years ago it was decided to modernise and reorganise the colliery on the basis of increased mechanisation both below and above ground, and one aspect of the modernisation scheme was the deepening of No. 3 shaft and the replacement of the steam winder by an electric skip winding equipment. The new winder, which was supplied by Metropolitan-Vickers Electrical Company, Ltd., came into operation in May, 1954. It is designed to serve the 516-yard and 580-yard levels simultaneously, and its initial duty requires an output of 4500 h.p. r.m.s. from the winder motors, but ultimately the power required will be 9000 h.p. r.m.s., which will be provided by duplicating the two motors installed at present.

Two attributes of the new winder installation are of special interest. It is the largest electric winder at present operated by the National Coal Board, being equipped (as illustrated here) with two 2250 h.p. motors driving via Bostock and Bramley type gears on to a double drum, one of which is clutched. It is also stated to be the largest winder in the world to be equipped with the Ward-Leonard Ilgner system of power equalisation, incorporating a flywheel and a hydraulic slip regulator. Because of the interconnection of electricity supply networks through the grid (so that in most areas winder acceleration peaks can now be accommodated by the supply system) and the interest now shown in friction winders in this country, it may possibly be the last equipment of its kind to be installed.

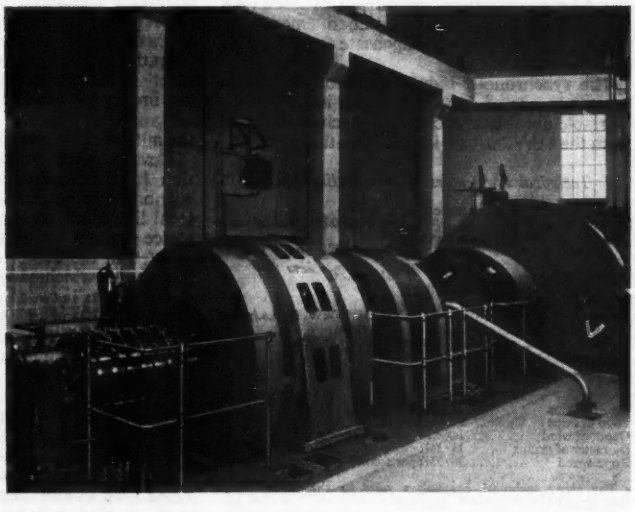
Some of the auxiliary equipment on this large winder is of special interest. For example, two exciter sets are installed: one, the main exciter, provides a constant voltage supply for the fields of the motors and generators and for the main control circuits; the other provides d.c. excitation for the stator of the synchronous induction motor driving the m.g. set, thus enabling dynamic braking to be applied to slow down the flywheel to about 30 per cent of full speed for normal stopping and in emergency. The exciter for the synchronous induction motor is driven from the driving motor end of the m.g. set. Duplicate motor-driven oil pumps are provided for brake oil pressure, main gear wheel oil spray, hydraulic coupling oil, m.g. set bearing lubrication, and Ward-Leonard controller oil servo system. The N.C.B. provided a water cooling system, incorporating duplicate pumps, for cooling the hydraulic coupling, m.g. set bearing oil, and the liquid starter.

The stator and rotor of the synchronous induction motor are both excited with direct current under different conditions, which will be apparent later from the procedure adopted to bring the flywheel up to speed and to shut it down.

The hydraulic coupling (supplied by the Fluidrive Engineering Company, Ltd.) is of the movable scoop design, but in this application the position of the scoop tube mouth is fixed at a point fairly close to the periphery. When the impeller and the associated motor run at sufficient speeds, the scoop tube mouth, which is housed in the scoop tube chamber, generates sufficient pressure to enable the oil (through which power is transmitted to the flywheel and generators) to be circulated through the coolers. To enable this pressure to be generated at starting, a considerable proportion of oil is admitted fairly quickly to the coupling working circuit; otherwise with the synchronous induction motor at full synchronous speed and the flywheel stationary, all the energy from the motor would be dissipated in the heat of the uncooled oil before it had a chance to circulate to the coolers. To enable the coupling oil to be kept at a reasonable temperature when bringing the flywheel up to speed, it is necessary, on equipments where the flywheel has a large amount of stored energy, to utilise both the slip of the



Two 2250/4500 h.p., d.c. motors driving the Ward-Leonard winder at Mosley Common Colliery. There is provision for doubling the power output by installing two similar motors coupled to a shaft extension at the other end of the twin drums



Ward-Leonard motor-generator set consisting of 2100 h.p. synchronous induction motor and two 1525kW d.c. generators (for normal excitation and for braking), flywheel and hydraulic coupling installed at Mosley Common Colliery

coupling and the slip of the motor, which is, of course, running as an induction motor. Once the flywheel is up to about 70 per cent of full speed and the oil has cooled slightly it is emptied out of the coupling, to cut down the peak as the motor is synchronised, and the exciter is connected to the rotor sliprings, the liquid starter having been disconnected. Oil may then be readmitted to the coupling until it is in the normal full position.

During normal winding oil is bled from the coupling and oil cooling circuit when the input current to the synchronous induction motor exceeds a predetermined amount; when the current is below that amount oil is forced into that circuit by means of a pump until the power required drops away and the coupling is full of oil.

To shut down the motor generator set the motor sliprings are disconnected from the exciter and connected to the liquid starter, and the stator is disconnected from the supply and connected to the dynamic braking exciter. Thus the motor now becomes an alternator, driven by the flywheel and loaded on to the starting resistance. The rotor current is kept at a reasonably high value by decreasing the rotor resistance as the speed drops, and the flywheel is thus slowed down in a matter of minutes. Final stopping can be accomplished with the assistance of a friction brake acting on the flywheel periphery.

Besides being the largest in Britain to be used on a winder slip regulator, this hydraulic coupling is also the first to have a fabricated steel casing and cast aluminium alloy runners and impellers. Earlier equipments at Mansfield Colliery and that transferred recently from Watnall to Whitwick Colliery are of cast steel construction.

With the oil that was used and the circulation rates obtained it was found desirable to use peripheral nozzles only in the coupling, and central nozzles, such as were used in previous equipments, proved to be unnecessary. It was found also that aeration of the oil caused loss of driving torque between the coupling and the flywheel and generators if the hydraulic coupling oil temperature was allowed to drop much below 50 deg. Cent.

To obtain satisfactory operation of the slip regulator and cut down overshoot of the input current (at the normal maximum setting current), an "anticipator," similar in conception to that used on steam turbine governors, is used. Because the slip regulator is essentially a simple piece of equipment, this method was chosen in preference to employing the latest servo techniques incorporating stabilising circuits. Oil-operated "Metrovick" single-engine spring brakes are used on the winder.

*Motors and Electrical Control Gear.*—A driver's desk, complete with the necessary signals, instruments and miniature depth indicators, is provided, and there are facilities for automatic winding. The speed control, which is on the Ward-Leonard system, utilises an orthodox oil servo-operated controller. Load measuring relays are used to help compensate for variations of speed with load.

The synchronous induction motor, which can be seen in one of our illustrations, is a "VAX" (variable automatic excitation) machine supplied from the 11kV busbars in the substation.

*Technical Particulars of Winder Equipment*

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|---|---|
| Output of two winder motors (initial) | 4500/9000 h.p. (r.m.s./peak) |
| Output of four winder motors (final) | 9000/18,000 h.p. (r.m.s./peak) |
| Speed of winder motors | 350 r.p.m. |
| Number of m.g. sets for final duty | Two |
| Output of each generator | 1525/3050kW (r.m.s./peak) |
| Synchronous speed of m.g. set | 750 r.p.m. |
| Output of m.g. set driving motor | 2100 h.p. (r.m.s.) |
| Weight of locked coil 6in circular rope | 10·566 lb/ft |

| | 516-yard level | 580-yard level |
|---|---|---|
| Tare of skips | 33,572 lb | 28,516lb |
| Load in skips | 26,880 lb | 26,880 lb |
| Depth of wind | 1640ft | 1830ft |
| Diameter of drums | 18·31ft | 20·42ft |
| Rope speed | 38·55ft per second | 43·0ft per second |

The above technical particulars refer to the initial duty. Both drums are now 20·42ft diameter.

An interlocking scheme which was incorporated in the winder anticipated recent requirements of the Ministry of Fuel and Power Inspectorate regarding gate interlocking, &c., where keps are not used. With these interlocks, if an obstruction is put into the shaft, such as the skip loading and unloading chute to bridge the gap between the skip and the shaft side or a platform, any attempt to take the brake off will trip the winder. If the obstruction is put into the shaft during winding, power is removed from the winder and the mechanical brake is applied. The opening of a gate, though it will not trip a winder in motion, will prevent a wind from being started. During men-winding, arrangements are made to prevent the skip-chute loading doors and other equipment associated with coal winding from being operated. During coal winding the gate interlocking equipment is made inoperative.

The main contractor for this winder was Metropolitan-Vickers Electrical Company, Ltd., and the mechanical parts were supplied by Vickers-Armstrongs (Engineers), Ltd., of Barrow. With the four 2250 h.p. motors required for the final duty it is believed to be the largest electric winder so far projected in the world.

*Surface Equipment.*—Besides the winder installation, the bulk of the surface electrical equipment at Mosley Common colliery was supplied by Metropolitan-Vickers Electrical Company, Ltd. The main 11kV distribution switchgear has provision for a further feeder for a possible extension to the existing winder, doubling its size.

The coal preparation plant, which is of the Barvoys type, is one of the largest in this country, having a capacity of 600 tons per hour. It is equipped with 169 electric motors which are provided with contactor control gear, and many of the processes are sequence interlocked. To correct the power factor of the colliery, electrical equipment synchronous motors were adopted, not only for the m.g. set but also for the fan drive and for some of the pump drives in the coal preparation plant.

# Research in the Post Office

AN Open Day was held on September 27 at the Post Office Engineering Research Station at Dollis Hill, where work is being carried out to improve Post Office services by studying new scientific effects, techniques and materials, and by the development of experimental systems and apparatus. While work of this general nature was carried out by the staff of the Post Office as long ago as 1870, a special research unit was formed only in 1909, with laboratories near St. Paul's. Purchased in 1917, the site at Dollis Hill first came into use in 1921, when some laboratories were installed in ex-Army huts. The main block of the present building was opened in 1933, and other blocks followed at intervals, the most recent being the Hydraulics Laboratory.

The staff now numbers about 1000. Besides Post Office research, some work is done for other Government departments, and information is exchanged with university, Government and industrial laboratories doing allied works. The whole of the Engineering Department is served by the library, which is housed on the second floor of the main block.

Probably the most notable event in electrical communications since the last Open Day at Dollis Hill, three years ago, has been the completion of the first transatlantic telephone cable. The British share of this joint undertaking with Canada and the U.S.A. was largely based on the work of the research station, which contributed to the design of the repeaters for the Newfoundland–Nova Scotia section, supplied long-life valves, and made exhaustive studies of components and materials. The work on submarine telephony continues, and current developments of improved valves, repeaters, and cables will be applied in an all-British cable, now being planned, from the U.K. to Canada. Other recent developments in long-distance communication include an improved method of reception of radio-telegraph signals and electronic equipment for the automatic correction of telegraph errors.

Developments in short-distance communication have been less spectacular, but they are economically important because exchange and local line plant accounts for a large part of Post Office capital expenditure. The station has assisted in the design and testing of a new telephone set, which gives better transmission and permits lines between subscribers and exchanges to be longer and of lighter gauge. The study of electronic switching techniques for telephone exchanges continues and is now co-ordinated with the work of the main exchange manufacturers. This work has had a novel by-product in the electronic random-number indicating equipment, ERNIE, for drawing prize-winning Premium Savings Bonds, which makes extensive use of transistor circuits. Transistors are also being used in amplifiers for trunk telephony and in a proposed new hearing aid for the National Health Service.

The expansion of the B.B.C. and I.T.A. television services, and the consequent growth of the Post Office television network interconnecting studios and transmitters, have maintained interest in the problems of waveform transmission by cable and microwave radio. The B.B.C. television service to the Isle of Wight is carried by a microwave link designed at the station, and another link using similar equipment carries multi-channel telephony 55 miles across the Moray Firth. New microwave and intermediate frequency test equipment has been developed for this work.

Other developments include a rolling mill for ultra-thin magnetic alloy strip and a single-position letter-sorting machine, twenty of which have been ordered after successful field trials. Quartz-crystal, frequency-standard equipment has been produced for Government laboratories or observatories in nine countries, including the U.S.A.

These and other activities were illustrated in the exhibits displayed on Open Day, some of which are described in the following paragraphs.

*Negative Impedance Amplifier.*—Between telephone exchanges situated at a long distance, amplification becomes essential, and as normal amplifying devices operate in one direction only, it has been usual to employ for every connection four wires and two amplifiers, i.e. one pair of wires and one amplifier for each direction. Amplifiers for two-wire lines which have in the past been developed have been expensive and have required elaborate arrangements to by-pass the signalling and dialling currents. More recently, the Post Office has been experimenting with a novel design of both-way amplifier, which is made to have the opposite effect to a length of line, i.e. to increase instead of decrease the magnitude of the current. Amplifiers of this kind are small and cheap, especially if transistors are used, and are likely to be installed in large numbers, halving the number of wires required on many routes between exchanges.

*Technology of the Alloy-Junction Transistor.*—Transistors have been in experimental use in Post Office telephone lines for over two years and as new equipments now in the design stage are introduced transistors will supplant valves in many existing applications; they will also appear in new applications, where the use of valves has been impracticable because of their size, power requirements, or comparative unreliability. Some of this equipment was being shown to the public for the first time.

Transistors for the telephone service will have to be of suitably high and consistent quality initially, and in use over periods of years. At the research station transistors obtained from British industry are subjected to searching tests, and detailed comparisons are made between these units and experimental units produced under closely controlled conditions in the laboratory. Effective sealing of the units in metal or glass enclosures is essential, for contamination by as little as 1 part in 100 million of impurity may have a serious effect on performance. Water is a dangerous contaminant and tests include immer-

sion of units in boiling water over periods of weeks. This gives an effective check on the method of sealing, and the high temperature increases the activity of any contaminant that may have seen sealed in, so that its effect on performance appears comparatively quickly.

Improved transistor structures are obtained by paying careful attention to crystal orientation, lapping and etching of the wafers—in many cases emitter and collector junctions are far from plane and parallel—and to alloying.

*Coaxial Cable Television Transmission.*—High-grade television links can now be provided over several miles of coaxial cable without frequency translation. A 6-mile demonstration link was shown which was equipped with video line amplifiers, waveform correctors, coaxial chokes, and a hum-suppressing device.

*Speech Interpolation.*—In order to economise on the number of channels required on trunk lines, a system has been devised which allocates a channel to a subscriber only during actual speech. This system was being demonstrated in the form of an exchange in which six four-wire trunks served ten pairs of "subscribers," represented for test purposes by records on magnetic tape of simulated telephone conversations. By using two actual telephones in place of one of the tape recordings, one could obtain a good impression of the serviceability of the exchange. It was stated that channels are "booked" within 10 milliseconds and "cleared" 17 milliseconds after the speaker has stopped.

*Thickness Measurements on Surface Films.*—Films produced on metallic surfaces by tarnishing and corrosion are of considerable practical importance, as they affect the performance of electric contacts in the switches and relays used in very large numbers in telephone exchanges.

In studying the properties of films it is very desirable to have a rapid means of measuring thickness, but optical methods are not always well suited to this purpose. In an apparatus devised at the research station the film is allowed to grow over a part only of the surface, and its thickness is measured as the height of the step at the edge of the film plateau. This is done by traversing the surface with the probe of an inductive gauge. The best form of traversing mechanism has been found to be one in which the specimen is carried by a single cantilever spring, driven by an electric motor through a simple speed-reducing and smoothing system, designed to avoid significant vibration of the specimen. Film thicknesses of the order of one ten-millionth of an inch may be measured to within two-hundred millionths.

*Diffusion Through Submerged-Repeater Glands and Seals.*—Transoceanic telephone links need repeaters at intervals to keep the signal at adequate strength. The cable enters the steel housings of these repeaters by polythene-insulated glands which, even at sea pressures up to 5 tons per square inch, must prevent the entry of any significant quantity of moisture to the interior throughout the expected twenty-year life of the system. To be acceptable, a gland must not allow more than four-millionths of an ounce of water vapour to leak during a test lasting three months. To measure such very minute quantities is obviously difficult, but it can be done in two ways. The first is the dew or frost point method, which utilises the fact that moisture will condense upon surfaces which are made sufficiently cold. In the second, a small proportion of weakly radioactive "water" (tritium oxide) is added to the common water used for the test; the mixture penetrates any leaks which may be present and its radioactive component can be estimated easily with sufficient accuracy on the other side of the gland.

*Laying of Submarine Cable and Repeaters.*—For over 100 years, deep sea cable has been made by taking a simple cable made of insulating material and copper and making it strong enough to lay in deep water by winding a layer of steel wires round it. This method of construction results in an uneconomical use of steel and an unnecessarily heavy cable. It also suffers from the serious disadvantage of tending to twist when under tension and to form kinks under certain conditions of laying or recovery.

These and some other defects have been overcome by the Post Office invention of a lightweight cable which has no external armour wires, all the strength coming from the heart of the cable itself. The cable is in fact built around a "neutral" (i.e. non-twisting) steel rope. Many problems in connection with such a basically new design (e.g. jointing and gripping without damage) have arisen but solutions have been found and satisfactory sea trials carried out. It is proposed to use a single cable of this kind with British design two-way rigid repeaters for the transatlantic telephone cable to be laid between the U.K. and Canada in 1961.

Although the lightweight cable is very much easier to handle than conventional cable, it cannot solve all the problems associated with laying a submarine cable equipped with a large number of rigid repeaters. The conventional method of controlling a cable when it is being laid by a cable ship is to pass three or four turns round a cylindrical drum or capstan, the shaft of which is equipped with a powerful brake, but the modern two-way repeater is housed in a steel cylinder about 9ft long, weighing half a ton, and obviously it could not pass round a normal paying-out drum. The procedure normally adopted involves stopping the ship, taking the strain of the cable on a steel rope, removing the turns of cable from the drum by hand, moving the repeater past the drum on a trolley and then replacing the turns of cable, all of which is a lengthy, laborious and somewhat risky process, involving a large number of personnel and careful co-ordination. Various bulky machines have been devised to simplify this problem and some have been brought to an advanced state of development but it would be very difficult to fit them on an existing cable ship.

The method being developed by the Post Office substitutes for the cable drum a number of sheaves coupled together mechanically and braked over which the cable passes in a zig-zag fashion without making any complete turns. A steel rope is spliced to the cable at points ahead of and behind the repeater so that when the latter reaches the laying gear the wire replaces the cable on the sheaves and the repeater passes to one side in a slack loop of cable. A scale model showed how the equipment could be fitted on the after deck of H.M.T.S. "Monarch."

One of the problems met in the working of a long submarine cable fitted with many submerged repeaters is that of localising any cable or repeater fault that may interrupt or degrade the performance of the system. A new device for providing information about the repeaters has been developed at the research station. From one land-based terminal station a signal is transmitted along the cable and this causes one repeater to send back to the terminal station a signal from which the condition of the repeater may be deduced; by changing the transmitted signal information may be obtained about each repeater on the route.

*The Metallurgy of Nickel-Iron Magnetic Alloys.*—Alloys incorporating nickel and iron as the main ingredients are used extensively in telephone systems, in the magnetic cores of coils and transformers. The development of components of reduced size and improved performance has led to a demand for alloys of a more consistently high quality and in thinner sections than manufacturers have hitherto been able to supply.

The magnetic quality is critically dependent on the proportions of the various metals in the alloy. It is difficult to maintain precise control of the composition at the high temperatures involved in the conventional process of melting and casting. Investigations at the research station have shown that the necessary control is more readily achieved by a powder-metallurgy process, in which the different materials, in the form of fine powder, are accurately weighed and then intimately mixed; the powder is converted into a solid billet, suitable for rolling, by compression and heat treatment.

Rolling and slitting machines capable of producing strip 0·00015in thick have been developed. The rolling was demonstrated on a four-high stand which could be fitted with work rollers of approximately ⅛in to 1in diameter. Slitting was carried out with circular blades of special design and loading, in order that the cut edges should be completely free from burrs which tend to pierce the subsequently applied insulating varnish. Techniques have been established for the heat treatment of the thin strip, so that its magnetic potentialities may be fully realised in use.

*Telegraph Error Counting.*—In the transmission of messages from point to point by radio-telegraphy, fading and interference cause errors to be introduced. A new experimental equipment was shown, which is designed to give as few errors as possible under bad propagation conditions. This may be particularly beneficial on circuits such as that between England and Australia, where direct communication is normally impossible for a part of each day.

The relative merits of different radio-telegraph systems cannot be assessed quickly in actual operation because of the unpredictable nature of the fading and interference experienced. A technique for laboratory testing has therefore been developed in which the number of errors occurring in a given time on a system is counted automatically. A device known as the fading machine is included in the transmission path and this introduces fading and interference similar to that obtaining on an actual circuit, but to a known and repeatable extent. Direct comparisons between different systems may therefore be made in a comparatively short time.

*Model of Steerable Aerial Array for 4–30 Mc/s.*—Current practice at receiving stations for the Post Office long-distance radio-telephone and radio-telegraph services necessitates, in general, a separate fixed-direction aerial system for each service. Each aerial system may require a space of several acres. Present experiments, as yet in an early stage, are aimed at developing a steerable short-wave aerial system capable of feeding many receivers simultaneously, which would permit a great saving of space. Equipment associated with this common aerial system would provide a separate outlet for each service, each outlet being "steered" electrically in the appropriate direction for optimum reception. If this direction should vary significantly due to movements of the ionosphere, from which radio signals are reflected in travelling from transmitter to receiver, the new system would enable the operator to steer both horizontally and vertically as required to maintain the service. This universal steering facility would also be useful in combating the effects of interference by unwanted short-wave transmissions.

The performance of an experimental aerial array, which could form part of a complete aerial system, is being studied by a model technique.

*Crystal Processing Laboratory.*—The crystal laboratories at Dollis Hill have for many years played a leading part in the development of quartz vibrators and of the techniques and machines for producing them.

Some of the vibrators produced were on show and covered a range of frequencies extending from below 1000 c/s to about 100 million c/s. A great deal of development work has been carried out, in particular on the Essen ring which is the most stable form of quartz vibrator so far developed. Many crystals of this type have been supplied to overseas customers for use in frequency and time standards.

The latest equipment for producing the very thin plates (down to 0·0025in thick) used for very-high-frequency work, were also on show. This included a cutting machine with an annular saw blade and a grinding machine designed to process cut slices down to their final thickness.

*Spectrum Analyser for the Band 25—140 Mc/s.*—Although a radio signal carrying intelligence is usually spoken of as having a certain frequency (or wavelength), it actually occupies a band of frequencies. The width of this band depends upon the amount of intelligence transmitted and ranges from 100 c/s or so for a single telegraph channel to several million c/s in the case of a signal carrying television or a large number of speech channels. With the aid of an analyser developed by the Post Office the spectrum, or distribution of energy within the band of the signal, can be examined. This enables the performance of the modulating equipment used to generate the signal to be assessed and adjusted. The instrument will also indicate whether the signal contains spurious components or whether it extends over a greater band width than is permissible.

*Small Quartz Clock.*—While previous designs of crystal-controlled clocks were rather bulky, the Research Station has constructed a small

clock with transistors in the divider and amplifier circuits. This instrument, which was shown mounted in a portable case, maintains an accuracy of about 1 second per week. Power consumption is about ¼W.

*Automation in Handling Mail.*—An interesting film shown to visitors during the open day gave a picture of the mechanical sorting facilities which have been installed at Southampton. There, the mail bags are emptied into a container from which the mail is taken by a conveyor to a rotating inclined drum with longitudinal slots. Letters fall through these slots, while the thicker parcels and newspapers slide down to the far end of the drum. After separating these two classes of mail the letters are further sorted as to size by being passed upwards between rollers which are so spaced that the higher rollers only pick up the long letters. Another machine with keyboards permits visual inspection and sorting according to destination. A further machine which was being demonstrated has been developed for checking the postage and applyir g the cancellation stamp. For this purpose the letters pass between two conveyor belts successively in front of two photo-electric sensing heads, the first causing the letters to be turned the right way up, the second establishing the correct position for the cancellation stamp, and the value of the postage stamp affixed, according to which the letters are finally sorted at the output end. Slip in the belt system is avoided by employing a single continuous length of belting.

## British Railways' Staff Training

AN essential factor in the success of the modernisation programme now in progress for British Railways will be the availability of fully trained staff at all levels to ensure that full advantage is taken of the new equipment as it comes into service. For this reason the British Transport Commission and British Railways have instituted a comprehensive training programme for staff who are, or will be, concerned with the provision, servicing and repair of the new forms of motive power. The magnitude of this training programme will be appreciated when it is pointed out that on the diesel traction side alone more than 1450 vehicles for multi-unit diesel trains will be in service by the end of this year and this number will be nearly doubled next year. There will also be some fifty diesel main-line locomotives delivered this year and more than 100 in 1958.

The diesel training programme has been arranged in two parts, one for staff personnel up to officer level at the British Railways Staff Training College at Derby, and the other at local schools in the Regions for drivers and fitters concerned with day-to-day operation and servicing of diesel traction equipment. For this training in the principles, methods and problems of diesel traction, a special new wing has been built and equipped in the college grounds at Derby and its courses are being attended by students from all Regions. These staff students are drawn from members of the three technical departments—the chief mechanical and electrical engineer's department ; the carriage and wagon engineer's department, and the motive power superintendent's department—and they range from mechanical foremen and inspectors to senior members such as assistant works managers and district motive power superintendents.

The courses are residential and the students live in the main college buildings. Theoretical instruction is given and instructional films shown in the college class rooms, while practical instruction and equipment demonstrations are carried out in the diesel wing. Between ten and twelve courses are arranged annually, each of from twenty to thirty students, according to the type of course required by the status of those attending. The courses vary in duration from a fortnight for foremen from the mechanical and electrical engineering and carriage and wagon engineering departments, up to five weeks for supervisory staff, such as shedmasters. The supervisory staff require considerable practical work with the demonstration equipment in the diesel wing, and are instructed in smaller numbers than staff with more advanced theoretical qualifications. The content of each course is substantially similar, but the syllabus is varied as to treatment and mode of instruction at five levels, again according to the status of the students and their requirements.

In the new diesel wing at the college the main instructional equipment is arranged in a hall some 94ft long by 40ft wide. This equipment includes components from high and medium speed diesel engines as used for rail traction ; components from mechanical, hydraulic and electrical transmission systems and control gear ; a half set of railcar power equipment (engine, gearbox, final drive and control gear) arranged for working against the normal vehicle braking system ; part of a twelve-cylinder high-speed engine, sectioned and motored ; a six-cylinder vertical high-speed engine (pressure charged) for dismantling and reassembling ; a turbo-charger for dismantling and reassembling, and two epicyclic gearboxes, one sectioned and one for dismantling and reassembling. The electrical equipment installed includes a universal electrical set comprising five machines in line which may be mechanically and electrically coupled together as required, and may be used as motors or generators. The machines are provided with shunt and series fields, either or both of which may be used. A variable resistance electrical loading unit is incorporated and also a mechanical brake. With this piece of apparatus the characteristics of various types of motors and generators can be demonstrated and the working of a complete diesel-electric traction power equipment simulated.

## Gear Machine Factory

THERE was opened last Saturday by Lord Lawson of Beamish, Lord Lieutenant of County Durham, the new building at Blaydon housing Churchill Gear Machines, Ltd. The company was formerly housed in the old locomotive shop of Vickers-Armstrongs, Ltd., in Scotswood, Northumberland, and the transfer of the plant, stores and offices to the other side of the River Tyne was accomplished during a fortnight's works holiday without, we are advised, any sacrifice of output.

The site of the building was at one time part of the bed of the river, but uncontrolled tipping has now built it up high above river level. The foundations consist of piles driven down through ashes for from 45ft to 65ft to enter the gravel of the river bed. Two hundred and fifty piles support the building, and further piles carry a concrete raft, which is the base for the heavy machine tools. The building has a floor area of 94,000 square feet, divided only by three rows of columns along the major axis, two of the bays being 36ft high and the other two 24ft. The roof is of multi-barrel vault design, cast *in situ*, and carries a heavy sheathing of vermiculite insulation. The walls are glazed from 5ft above floor level upward, and very little artificial light is necessary in the daytime.

As has been said, the structure is devoid of interior partitions, and the advantages of this for supervision and materials flow have been exploited, there being no divisions between goods inward bay, machine shops, assembly, and even the tool room. Vacuum dust extraction on the tools is relied upon to maintain cleanliness for the later stages of manufacture : a water-wash spray booth is provided. Partitions do, however, constitute the offices, established in one of the 24ft bays pending construction of a separate building, and isolate the cutter production department. Within the latter is a closed room housing Maag mechanical and Societe Genevoise optical inspection magnifiers.

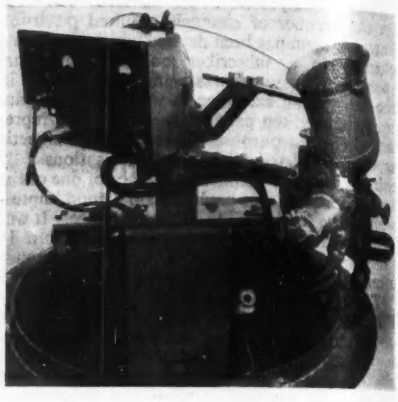
Electricity supply to the factory is at 20kV to a substation on the site, and the storage tanks and pump unit for the oil heating plant are separated from the building. Dravo oil-burning air circulators can maintain an internal temperature of 65 deg. Fah. ±2 deg. down to an ambient of 30 deg. Fah when the plant is running.

We were able to tour the factory immediately after its opening and were impressed by light interior resulting from a white finish on the concrete. Among the machines in hand was a prototype of a 16in version of the Churchill "Rigidhobber."

## Plate Shell Welding Machine

A BOILER end and flue welding equipment which has been developed by Quasi-Arc, Ltd., Bilston, Staffs, can be seen in the accompanying illustration. It can be used on shells from 3ft 1in to 6ft diameter and consists essentially of one of the firm's "Unionmelt" D.S. heads mounted through a bracket on a self-propelled carriage. This carriage is fitted with special traverse or driving wheels and support rollers, through which the equipment is hung from the edge of the shell.

The two traverse drive wheels rest on the edge of the boiler shell whilst the tractor carriage, which hangs down in a vertical position in the shell, has adjustable guide and support rollers at its bottom end. The traverse wheels are



**Boiler end and flue welding machine for plates from ¼in to 1¼in thick, and shells 3ft 1in to 6ft diameter**

adjustable to suit the shell diameter and propel the carriage at steplessly variable speeds from 2in to 25in per minute round the shell. During welding the position of the nozzle in relation to the seam is maintained by a vertical guide wheel running on the boiler end and a horizontal guide wheel on the side. The horizontal wheel runs on the inside of the shell when the machine is used for welding flues and on the outside of the plate when welding boiler shells.

The standard D.S. head used is complete with a control panel, swivel and rocker mounting, spool and hopper. The complete equipment weighs some 300 lb and is stated to be suitable for plates from ¼in to 1¼in thick.

## Fuel Research

THE reports of the Fuel Research Board and of the Director of Fuel Research for 1956 show that the Fuel Research Station has carried out much work on the synthesis of oils and chemicals from coal and on the gasification of coal and coke. The need for ships and tugs to avoid making smoke when in harbours and docks has led to some investigations of coal-fired steam-raising plants, and it proved possible to reduce by about 80 per cent smoke emission from a forced-draught and a natural-draught tug-boat. That smoke still persisted was found to be due to the boilers being overloaded, and primary air having to be supplied at the expense of secondary air: this increase in steam production was achieved at an appreciable sacrifice in efficiency. Domestic coal-burning plant was also the subject of continued activity ; the efficiency of the double-cased convector fire, high in any case, was shown to be liable to an increase of about 15 per cent by adoption of forced convection. Pollution studies included carbon monoxide sampling in London streets ; concentrations high enough to be hazardous to health other than in short exposures were occasionally found in the Blackwall Tunnel. An American proprietary catalytic combustion chamber, a welded stainless steel vessel filled with pellets which become catalytically active above about 500 deg. Fah., has replaced the silencer on a 10 cwt van, and its effectiveness is being measured at intervals. Some preliminary experiments on exhaust gas analysis showed much of the matter collected by condensation and absorption to be unburnt fuel.

# Industrial and Labour Notes

### T.U.C. and the Bank Rate

At a meeting last week, the general council of the Trades Union Congress approved a statement setting out its views on the effect of the rise in the bank rate and of the consequent economic measures announced by the Government. This statement, which was issued after the meeting, said that the general council recognised the importance of maintaining international confidence in sterling, and that the trade union movement had never been unwilling to support even distasteful measures which were seen to be necessary and were equitable in their impact. The general council thought it was clear, however, that recent speculation against the pound had not arisen primarily from the internal situation in the United Kingdom but from the international economic situation, in which the policies of several leading countries were involved, and which would not be rectified by the United Kingdom taking action alone.

In the present situation, the T.U.C. statement continued, there was no evidence that the level of industrial activity was higher than was desirable or that manpower and other resources were generally subject to undue strain. The measures announced by the Government, the statement asserted, threatened to result in a lowering of activity in this country and in a rise of the level of unemployment which was likely to be persistent. If that occurred, the T.U.C. claimed, the benefits of increased output and living standards which might have been expected from capital investment of recent years would not be realised. The general council added that it was bound to express its apprehension at the effect of the Government's actions upon the level of employment and productivity, and therefore upon the confidence not only of working people, but of the industrial community as a whole.

### Economic Change

In the September issue of *Bulletin for Industry*, a document which is prepared by the Treasury, economic changes which have occurred in this country since the war are surveyed. In the last ten years, it is pointed out, some industry groups have become relatively larger, as measured by the income they provide, and some smaller. The two big changes are the reduction in the size of agriculture and the increase in the size of manufacturing. In 1948, agriculture provided 7 per cent of all the incomes from production and trade in this country, whereas last year the percentage was 5 ; manufacturing, on the other hand, rose in the same period from 41 to 44 per cent. Building and contracting rose, as did also gas, electricity and water. The distributive trades lost a little, their proportion being 15½ per cent in 1948 and 14¼ per cent last year. The *Bulletin* adds, however, that the four " goods-producing " industries taken together, that is, agriculture, mining, manufacturing and building, maintained their share (60 per cent) of all production and trade in 1956.

The *Bulletin* goes on to explain that between 1948 and 1956 the average wages of operatives in industry rose by 73 per cent, and that in the same period the average salaries of administrative, technical and clerical workers increased by 48 per cent. It is pointed out also that in 1956 labour costs per unit of output were 42 per cent higher than in 1948, and that gross profits and other trading income per unit of output were 33 per cent higher. Last year, wages and salaries rose 8 per cent, while gross profits went up by 4 per cent. But, according to the *Bulletin*, labour costs have not risen evenly. Over the whole period 1948–1956, they have gone up much more in mining and in building and contracting (51 per cent each) than in manufacturing (39 per cent). In gas, electricity and water, labour costs have risen comparatively little (21 per cent), though in 1956, when manufacturing output fell, labour costs per unit rose faster (10 per cent) than they did in the other three sections (7 per cent in mining, 5 per cent in building and 2 per cent in gas, electricity and water).

### Wages and Hours

The Ministry of Labour has now published detailed results of its latest inquiry into the average weekly earnings and hours of manual workers in the manufacturing industries and some of the principal non-manufacturing industries in the United Kingdom. The survey related to the second pay-week in April, and approximately 68,900 establishments provided information. The total number of workers covered by the returns made was about 7,000,000. The nationalised industries, agriculture, shipping, port transport, and the distributive trades, were not included in the inquiry.

The statistics which the Ministry has surveyed show that in the second pay-week of April the average earnings in all the industries examined were : men, £12 1s. 6d.; youths and boys, £5 5s.; women (18 and over), £6 5s. 10d., and girls, £4 3s. 11d. In the manufacturing industries only, the figures were : men, £12 8s. 11d.; youths and boys, £5 2s. 2d.; women, £6 6s. 3d.; and girls, £4 4s. 4d. When the figures for this latter group of industries are broken down, it is shown that in " engineering, shipbuilding and electrical goods " the average earnings were : men, £12 13s. 5d.; youths and boys, £4 19s. 11d.; women, £6 14s. 6d.; and girls, £4 6s. 2d. Taking again all the industries included in the survey, it is shown that between October, 1956, and April last, the increases in average weekly earnings were : 1½ per cent for men, 2 per cent for women, and 3 per cent for youths and girls.

As to the hours worked in the second pay-week of April, the figures given for all the industries examined are : men, 48·5 ; youths and boys, 44·9 ; women, 41·5 ; and girls, 42·4. The figures for the manufacturing industries are just about the same, those for the engineering, shipbuilding and electrical goods group being : men, 48·7 hours ; youths and boys, 44·6 hours ; women, 42·4 hours ; and girls, 42·9 hours.

### Research and Management

The twelfth " national management " conference organised by the British Institute of Management is to be held at Bournemouth on November 6, 7 and 8. The principal theme underlying all the discussions is to be the speedier application of research leading to better methods of management.

The opening address will be given by Lord Monckton, and at one of the plenary sessions an address on " Research as an Investment " is to be delivered by Dr. Alexander King, who is the deputy director of the European Productivity Agency. In sectional meetings some of the subjects for discussion are : the universities and management research ; industry and technical progress ; the demands made upon management by automation, and the problems of employing older men. The aim of the conference is aptly set out in an introduction to the advance programme, which says : " In Britain more than any other country it is essential that a high level of research should be maintained, but still more that its results should be readily available to industry and applied without a time lag."

### Coke Research

A delegation from the British Coke Research Association is now visiting the U.S.A., under the leadership of Mr. Leslie O'Connor and Mr. G. W. Lee, chairman and director respectively of the Association. The last visit to the U.S.A. by experts from Britain's coking industry was made in 1947 ; the present delegation is studying the technical and economic developments of the last ten years.

Among the matters which members of the delegation are studying are the design of coke oven and ancillary plant ; the general economic position of the coking and by-product industry ; the main lines of research work and thought in the U.S.A. devolving from the treatment of coal and coke, and the possibilities of the development of new methods of making coke and iron. During their four weeks' tour, members of the delegation will visit coke-oven plants and iron and steel works as well as research organisations and laboratories.

### British Standards Institution

The annual general meeting of the British Standards Institution was held in London on Tuesday of last week, September 24. Sir Herbert Manzoni, the president, in presenting the annual report (THE ENGINEER, September 13, page 371), said that it dealt with a " record year." Compared with the preceding five years, more standards had been issued, there had been a much larger distribution of them, and both committee meetings and subscribing members had been more numerous. The Institution, Sir Herbert added, was keeping abreast of scientific progress, as could be seen from the references in the annual report to automation, nuclear energy and air pollution.

As to the future, Sir Herbert continued, it was evident that the British Standards Institution's efforts should now turn increasingly to the pursuit of the practical advantages which flowed from the application of standardisation. During the past year, about thirty meetings had been held at which invited audiences at management level had discussed the benefits to production of the " three S's," namely, standardisation, simplification and specialisation. A start had also been made, Sir Herbert said, with the support of the Ministry of Education and certain technical colleges, with training courses for industrial standards officers.

Sir Herbert Manzoni was re-elected president ; Mr. John Ryan was re-elected vice-president.

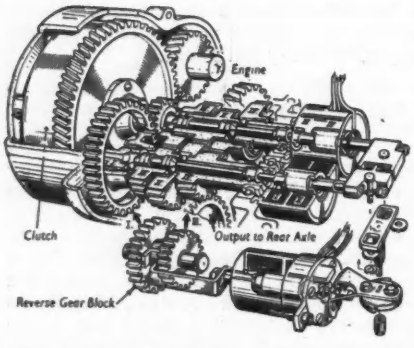
# International Motor Show at Frankfurt

No. II—(*Concluded from page 468, September 27*)

IN our last issue we dealt with cars with cylinder capacity of more than 500 c.c. We mentioned that in the category of medium-size and small cars, i.e. those of less than 1·5 litre capacity, the design is flexible and far from being standardised. In spite of the divergency of opinions, Continental designers are unanimous in their opinion that for cars of less than about 8ft wheelbase the erstwhile layout, characterised by front engine and rear drive is outdated, and it is worth mentioning that, since the end of the last war, no small car has been newly designed and built in Europe which conforms to the conventional British conception. This tendency applies even more to the layout of very small vehicles of less than 500 c.c. cylinder capacity, i.e. cars the design of which is mainly influenced by contemporary motor-cycle practice. There were still a number of three-wheelers and four-wheelers with narrow rear track to be seen at various stands, but it seems that, even in the case of the smallest vehicles, the design will eventually turn to cars with equal track fore and aft, preferably fitted with a differential. Such a layout undoubtedly offers the most promising solution in regard to optimum space utilisation, minimum weight and economic production.

A good example of a small car which, since its introduction some three years ago, has become quite popular in Germany, is the "Goggomobil," made by Hans Glass K.G., and presented at the show as a particularly well-styled cabriolet. This little car, illustrated below, has a wheelbase of 6ft and a kerb weight of less than 8 cwt.; it is powered by an air-cooled 300 c.c. two-stroke engine. The engine is transversely mounted at the rear of the all-steel body and transmits the torque via spur wheels and universally jointed half shafts to the coil sprung rear wheels.

The gearbox of the "Goggomobil," like that of all front-wheel-drive and rear engine cars, has indirect gearing in all ratios, a fact which allows the designer to employ different means of effecting the gear change. The above mentioned cabriolet is equipped with the solenoid-operated preselective four-speed gearbox "Selektromat," made by Getrag G.m.b.H. and illustrated. The gearbox has two hollow shafts, and the mating wheels of each individual ratio are so arranged that, in the neutral position, one wheel is freely rotating on one shaft whilst the other one is solidly keyed to the other shaft. A control rod with two cones on each end is located in the bore of each shaft; when shifted in either direction one of the cones makes contact with a row of steel balls carried in radial bores of the shaft. The axial pressure of the cone pushes the balls partially out of the cylindrical surface of the shaft and into contact with corresponding indentations machined inside the hub of the rotating gear wheel, thus locking the latter to the shaft. By moving the two control rods alternatively in opposite direction, all four forward gear ratios can be successively engaged. Each rod is operated by a solenoid, electrically connected with a small lever at the steering column, which preselects the required circuit; the solenoids, however, are only actuated when the preselected circuit is being energised by a switch operated by depressing the clutch pedal. The two control rods are mechanically and electrically blocked to prevent the simultaneous engagement of two gears, and the reverse gear is engaged by the axial displacement of a spur wheel; this gear shift is also effected by a solenoid.




**"Selektromat" electrically operated gearbox, showing method of gear selection**

Apart from the 300 c.c. model with a rear-mounted two-stroke engine, the firm also showed a new front-wheel-drive car fitted with an air-cooled 25 h.p. horizontally-opposed two-cylinder four-stroke engine of 600 c.c. The car has an all-steel body, bolted to a stiff floor structure, independent all-wheel suspension with coil springs and double-acting telescopic dampers, and is equipped with a non-synchronised four-speed gearbox. It has a wheelbase of 6ft 8in, a track of 3ft 10in and weighs about 11 cwt.

An interesting small car which is shown on this page is the "Janus" made by the Zündapp Works, manufacturers of motor-cycles and motor-scooters. This vehicle, quite obviously influenced in its general layout by motor-cycle practice, is bold and unorthodox in its conception and ingenious in detail design. It has an almost symmetrical body with one door at the front and one at the rear, giving access to the front and rear bench seats, which are arranged back-to-back so that the rear passengers are facing backwards. The front entrance of the "Janus" differs from that of the "B.M.W. 600" in as far as, at the opening of the door, the steering wheel and column remain in position on an arm attached to the body. As the low horizontal engine and the gearbox are mounted midships between the backs of the front and rear bench seats, accessible by hinging the seat backs, there is sufficient leg room for four adult passengers. Considering that the car is only 9ft 8in long and 4ft 8in wide, the floor utilisation is very good indeed.

The "Janus" is built in integral all-steel construction, has a wheelbase of 6ft 10in and a weight of 8½ cwt. The independent suspension has short leading arms, joined by an anti-roll bar, at the front and double trailing arms at the rear, employing fully enclosed coil springs with concentric double-acting dampers.

The car is powered by a horizontal single-cylinder air-cooled two-stroke engine of 250 c.c. capacity; it is transversely mounted in the centre of the car and develops 14 h.p. at 5000 r.p.m. The torque is transmitted from the engine through a chain to the gearbox, and from there via an open propeller shaft to the final-drive casing attached to the floor structure and to the swing axles.

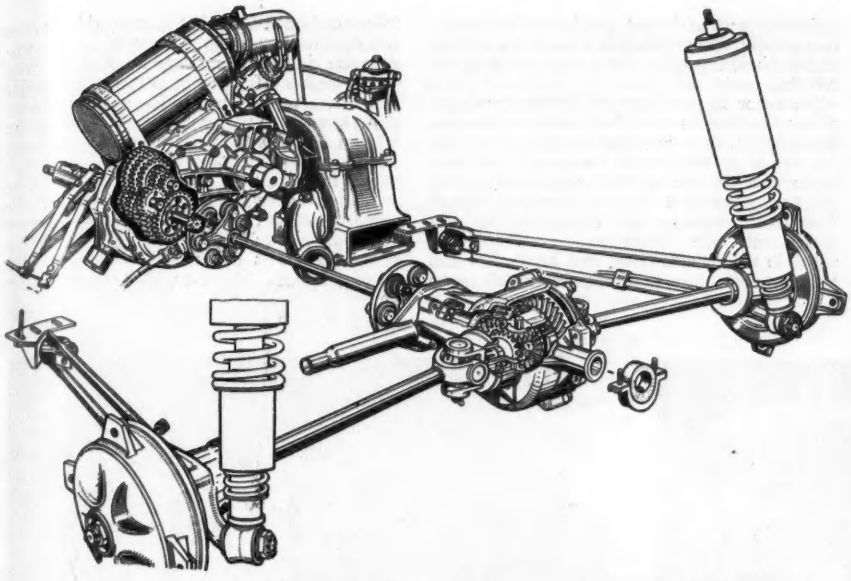
The four-speed gearbox shown opposite was originally designed for motor-cycles and is only suitable for transmitting a moderate torque, but is of surprising simplicity. It has two shafts, and one set of the narrowly spaced gearwheels is solidly keyed to the driving shaft, whilst the corresponding set on the driven shaft is free to rotate in the neutral position. The hubs of the gearwheels on the driven shaft have lenticulated bores with internal splining in the narrow part of the bore. The driving shaft is also splined for a short length, corresponding with the width of the splines in each individual gearwheel. Axial shifting of the shaft relative to the wheels causes the splined part of the latter to slide into engagement with the corresponding part of the wheel hub, thus locking the wheel to the shaft. A further axial displacement in the same direction moves the shaft out of engagement; before passing on to the next gear ratio, the splined part of the shaft enters the wider cylindrical part of the wheel hub, thus resetting the transmission to its neutral position. This design is one of the most interesting of German miniature cars, though it is probably rather under powered.

## Commercial Vehicle Design

In contrast to the more international character of the motor-car display the great majority of the exhibits in the commercial vehicle section were of German origin. Germany's production of dual-purpose and commercial vehicles this year has increased at a higher rate than that of motor-cars, but the proportion of exports to total production, amounting to 31 per cent, has slightly dropped compared with that in the same period of 1956. Table III, presenting this year's production figures arranged according to the various classes of vehicles, shows that dual-purpose cars and light vehicles up to 1 ton in load-

**The "Janus" is symmetrical in its seating disposition**

**The Goggomobile "TS" coupe is a recent introduction**



**The gearbox of the "Janus" engine is unusual in being remote from the final drive**

ing capacity accounted for about 60 per cent of the total production. In spite of these apparently quite satisfactory production figures, the present economic position of the manufacturers of the heavier commercial vehicles is not an easy one. Business in the home market has been severely affected by credit restrictions, and by the uncertainty prevailing in the field of heavy goods vehicles in Germany owing to new traffic regulations. This year new registrations in Germany of lorries have dropped by 15 per cent and those of trailers by 20 per cent. This decline mostly applies to goods vehicles for payloads of 7 and more tons, and it is reported that in this particular field production figures this year will probably be 15 per cent lower than in 1956. It must appear, however, that at least some manufacturers were able to expand exports and to make good the drop in the turnover of goods vehicles in the home market.

TABLE III—*Production of Commercial Vehicles in Germany for the First Six Months of* 1957 *Compared with* 1956

| | 1957 | 1956 | Per cent change |
|---|---|---|---|
| Dual-purpose vehicles ... ... | 42,259 | 32,022 | +32 |
| Commercial vehicles ... ... | 93,687 | 77,889 | +16·4 |
| Up to 1 ton loading capacity | 40,064 | 34,092 | +17·5 |
| From 1 to 3 tons loading capacity | 20,006 | 16,298 | +22·8 |
| More than 3 tons loading capacity | 30,620 | 27,499 | +11·3 |
| Public service vehicles ... ... | 2,726 | 2,458 | +10·9 |
| Trollevbuses ... ... ... ... | 13 | 10 | — |
| Road tractors ... ... ... | 258 | 343 | −22 |
| Total ... ... ... ... ... | 135,946 | 109,911 | +21 |

Most of the German light vehicles are being made by the big manufacturers of motor-cars, and only a few firms are making light goods vehicles of specialised character. It is obvious that the great majority of double-purpose cars, station wagons and delivery vans made by any of the big manufacturers closely follow the constructional principles of their respective private car designs, utilising as far as possible the same or suitably modified components as engines, gearboxes, suspension units, &c. This tendency applies by no means to vehicles of the more conventional layout only, but practically to all makes irrespective of the design and the mounting of the engine, or the drive arrangement. Front-wheel drive cars like the D.K.W. of Auto Union, the Goliath and the Lloyd are particularly suitable for conversion into light delivery vans as the forward position of the complete power transmission unit gives easy access to a low, unobstructed loading platform.

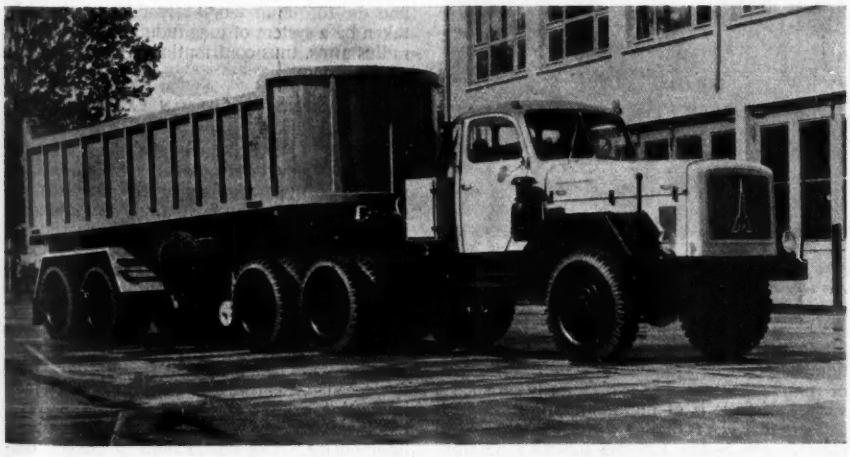
Good examples of such vehicles were exhibited at the stands of the above-mentioned firms, most of these models being equipped with forward control, the driver's cab extending over the engine. The same basic layout is also being used for small buses with a capacity of up to ten passengers, vehicles which have become quite popular on the Continent whenever a small volume of traffic does not justify the service of a larger bus.

In case of vehicles with rear-engine mounting the problem of easy access to the loading space is, of course, more difficult, but, as the examples of the V.W. transporter and the Fiat "Multipla" showed, suitable designs giving access through doors on the nearside or on either side have been developed.

Turning to the category of goods vehicles of more than 1 ton carrying capacity, we notice that in this field the design is more or less standardised and follows conventional lines. Any special demands of the customer as to body-work, equipment and so on are generally satisfied by dealers, bodybuilders and similar specialised firms. With the exception of the Opel goods vehicles and some medium-sized public service vehicles, the majority are fitted with diesel engines, generally of the precombustion chamber type. In the field of vehicles of less than 3 tons the bonneted vehicle is still popular, but forward or semi-forward control is definitely gaining ground in all trucks and tractors made for the home market. The industry has made great efforts to overcome the resistance of the drivers to this type of control by more comfortable seating arrangements, better ventilation and sound-proofing. A great deal of research has been devoted to the problem of noise reduction, as one of the major factors governing the driver's fatigue, and it is stated that, in cases concerning the combination of air-cooled diesel engines and forward control, it has been possible to reduce the noise inside the driver's cab by as much as 10 phons by carefully introducing sound insulation. It goes without saying that in the category of all goods and public service vehicles all the customary means of reducing driving fatigue are employed, such as synchronised gearboxes or pneumatic help for the gear-change and clutch operation, servo-assisted brakes and, in the case of the heavier vehicles, power-assisted steering.

We have already mentioned that the demand for heavy goods vehicles in Germany has considerably dropped recently owing to the uncertainty regarding the future constructional conception of this type. New traffic regulations, introduced by the middle of last year, severely curtail the permissible axle loading, the overall dimensions of vehicles, and, in addition, require a minimum engine output in relation to the total laden weight. With regard to the latter stipulation the regulations demand a minimum of 6 h.p. per ton of total laden weight. As the total weight of a truck-trailer combination is limited now to 24 tons, an engine of about 150 h.p. is required, a demand which, in most cases, can be met by the industry without any great difficulties. The demands for limiting the weight and the overall dimensions of the vehicles are not easy to satisfy without endangering the economic structure of the heavy goods road traffic. As the overall length of a truck must not exceed 33ft, that of a bus or coach 40ft, and that of a truck-trailer 46ft, and the permissible maximum axle loading is 8 tons per axle, it is clear that these restrictions are bound to have a decisive effect on the construction of goods vehicles. Although the industry is optimistic and expects that the restrictions, which are generally regarded as ill-conceived, will have to be reconsidered to bring them in line with the Geneva International Traffic Convention, there is no doubt that they are causing considerable inconvenience, not only to prospective buyers, but also to the industry, which, for the time being, has to produce different designs for the home market and for export.

It is interesting to note how the German industry of heavy goods vehicles has been reacting to mitigate the impact of the new traffic regulations by constructional means. The restrictions concerning the maximum axle loading have made the designer conscious of the necessity of improving the ratio of unladen weight to payload which, in Germany, at about 1·4 : 1, used to be considerably higher than in this country. Some progress has been made in the construction of lighter chassis and bodies—the latter sometimes made of light metal—without sacrificing strength. Further, the restrictions imposed on the overall dimensions have stimulated the interest in construction providing a maximum of floor utilisation, and have quite decisively led to the adoption of formerly unpopular layouts as forward-control and underfloor engines. Apart from the pioneer in Germany of underfloor engines in goods vehicles, Büssing G.m.b.H., other firms like Henschel and Sohn G.m.b.H. have now adopted



**All-wheel-drive with final reduction in the hubs characterises this Magirus Deutz "Uranus" off-the-road tractor, seen with a Fruehauf trailer giving a train weight of 60 tons**

this form of engine mounting for goods vehicles, and Daimler-Benz, originally the protagonists of rear-mounted engines for public service vehicles, for their latest city buses.

Another design which in future is likely to find a wider application in Germany is the articulated vehicle; there were a number of well-designed new tractors at the stand of most manufacturers of heavy vehicles, and also a number of attractive trailers, the latter generally built by specialist firms of body builders. However, there seems to be a certain lack of adequate collaboration between the manufacturers of the tractors and those of the trailers, a condition which is essential as the characteristics of these two units have to be carefully matched to obtain an optimum of economic and operational conditions. Another obstacle which, so far, has adversely affected a more general introduction of the articulated vehicle is the fact that, except in the case of NATO military vehicles, no design of a generally accepted standardised trailer coupling has been developed.

The foregoing remarks apply exclusively to the heavier goods vehicles as the regulations concerning public service vehicles do not contain any drastic changes; besides, lightweight construction has always been practised in German bus and coach design, and there seems to be little scope for further weight saving. The former traditional construction of buses with bonnets has practically disappeared from the roads, and has been replaced either by forward-control buses, mainly for light and medium class vehicles, or by underfloor or rear-engine buses and coaches in the heavier class. In this latter category there is some definite tendency towards the integral body-cum-chassis construction; the skeleton layout with steel or light metal panelling predominates, but there were some good examples of stressed-skin design, among them an underfloor city bus by Henschel and Sohn for 80 to 100 passengers entirely built of light metal.

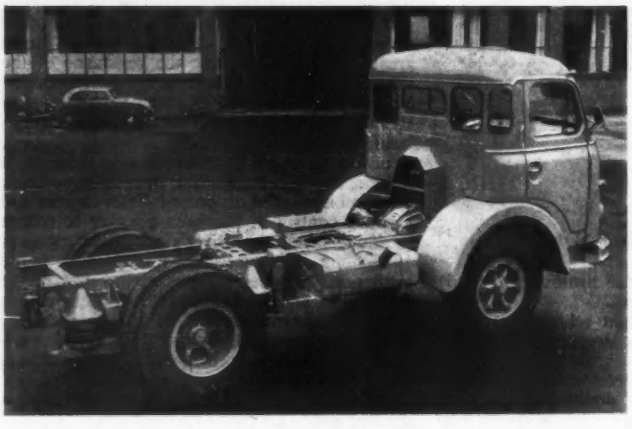
The same tendency which applies to heavy goods vehicles, namely to reduce the physical effort of driving, is naturally still more pronounced in public service vehicles. A fully automatic transmission which is finding increasing application in city buses is the Z.F. "Hydromedia" two speed transmission. It consists of a simple converter coupling with a maximum conversion ratio of 2·55 : 1 and of a gearbox of the layshaft type, the two forward ratios of which are coupled to the respective shafts by oil-operated multi-disc clutches; the reverse gear is engaged by a dog clutch. Oil which serves the converter housing as well as the gear couplings is circulated by two gear pumps. The gear shift is controlled by solenoid-operated valves under the influence of a torque-responsive element (the position of the accelerator pedal), and a speed-responsive element (a small a.c. generator on the speedometer drive), both affecting the control relay via a transistor circuit.

Epicyclic gearing is not employed in German transmission design except in a few cases of wheel hub reduction gearing for the heaviest goods vehicles.

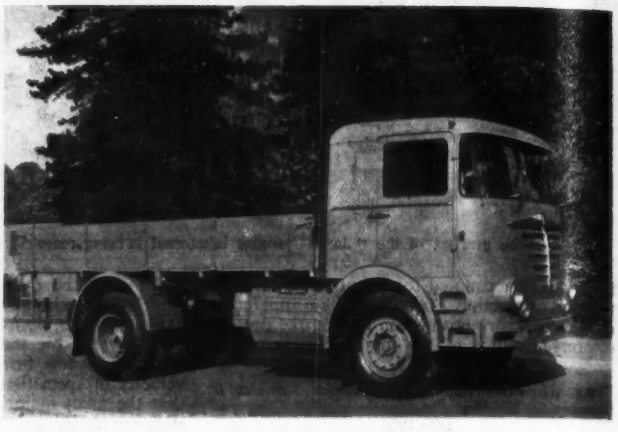
No major changes are noticeable in the design of diesel engines, in which field the precombustion chamber or swirl chamber dominates, mainly because of its insensitivity to fuels of different grade and because of the valuable properties of the single-hole pintle injection nozzle. Two-stroke engines were represented by two makes only, the Krupp engine with exhaust valves in the cylinder head, and by the V-4 and V-6 port-controlled Ford engines, which, since their introduction two years ago, have proved quite successful.

After the valuable work of Maschinenfabrik Augsburg-Nürnberg (M.A.N.) to reduce the engine noise by eliminating the typical "diesel knock," other manufacturers have followed suit, and some of the latest engines, among them the air-cooled, precombustion chamber engine of Motorenwerke Mannheim (M.W.M.) are noticeable because of their smooth running. Turbocharging of engines has not found any wider application, the main obstacle to a more general use being a certain sensitivity of the rotor bearings. Most manufacturers now claim that their diesel engines are capable of digesting practically all grades of fuel, i.e. gas, oil, petrol, paraffin, lubricating oil, and so on. From a purely economical point of view the capacity of an engine of running more or less satisfactorily on such a variety of fuels is of minor importance, and it appears that NATO military considerations were mainly responsible for the intensive development work in this particular field.

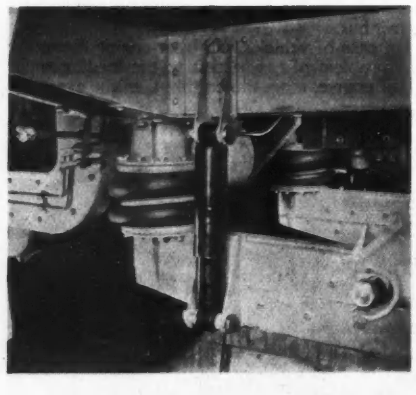
Wheel suspensions of goods vehicles generally follow orthodox lines, but in case of large buses and coaches, particularly those of integral construction, independent suspension at the front and, though less frequently, at the rear, is coming into use. A genuine surprise at the Frankfurt show, however, was the number of public service vehicles fitted with air suspension. Although several systems of "air springing" have been known in the U.S.A. for some time, most Continental designers, while aware of the valuable properties of this system, were doubtful whether its adoption would be economically worthwhile as it necessitates considerable modifications to existing designs. However, after the satisfactory conclusion of prolonged development work carried out by Continental Gummi-Werke A.G., a number of manufacturers decided that for buses where the payload equals or exceeds the unladen weight of the vehicle and, where a high riding comfort is essential, the advantages of the air suspension would justify the considerable constructional effort and the higher first cost.



**Henschel forward-control tractor with 180 h.p. six-cylinder diesel engine and air suspension**



**Büssing 6·5-ton truck with six-cylinder, 145 h.p. underfloor diesel engine**



**Air suspension unit with telescopic damper and attitude control**

In their general layout the air suspension designs of all German vehicles at the show were more or less similar. They consisted basically of rubber bellows attached to the chassis or the body structure (as a rule two bellows for the front and two for the rear suspension), each bellows being assisted by one telescopic double-acting damper. The bellows are interconnected by pipelines leading to an air receiver, which is kept at constant pressure by an air compressor. Valves in the pipelines control the air pressure of each individual bellows so that the floor level of the vehicle maintains a constant height from the ground irrespective of any variations of the axle loading. As the bellows are capable of taking vertical loads only, the horizontal forces and the torque and brake reactions have to be taken by a system of longitudinal and transverse radius arms, thus contributing to the complexity of the system.

### Examples of German Commercial Vehicles

Büssing G.m.b.H., one of the oldest manufacturers of heavy commercial vehicles and the pioneer of the underfloor engine in Germany, displayed not less than five entirely newly designed buses and trucks, all of them fitted with six-cylinder diesel engines ranging from 110 to 170 h.p. Among the goods vehicles we particularly liked a 7-ton forward-control chassis which is also obtainable with a shorter wheelbase as a tractor, or, with all-wheel drive, as a tipper. It is fitted with a vertical 7·15-litre engine, developing 145 h.p. at 2500 r.p.m., and with a five-speed synchronised gearbox. The most interesting exhibit at the Büssing stand was a ninety-passenger city bus with a 110 h.p. underfloor engine. The bus is built in integral construction, having a welded steel skeleton to which the stressed stainless steel panelling is

welded. The bus is equipped with air suspension of the kind previously described, and has an unladen weight of about 6 tons. Another city bus of integral steel construction with a maximum carrying capacity of 107 passengers and a 170 h.p. underfloor engine (equipped with a compressed air starter) was also fitted with air suspension.

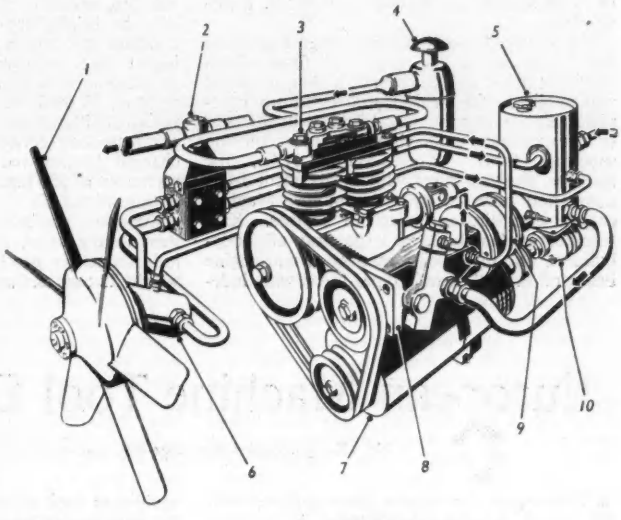
At the stand of Daimler-Benz the most interesting exhibit was a city bus with a 200 h.p. underfloor engine, designed to carry up to 120 passengers (ninety standing and thirty seated) in rush-hour traffic. The vehicle, less than 40ft long, is built in integral steel construction, and is equipped with air suspension, power steering and a four-speed synchronised gearbox, or (optionally) with a Z.F. "Hydromedia" transmission. The six-cylinder 10·8-litre engine, which has a central precombustion chamber and four valves per cylinder head, and is carried amidships together with the gearbox, has an output of 200 h.p. at 2200 r.p.m. The torque is transmitted via a dry single-plate clutch to the hypoid rear axle through an open propeller shaft; a second propeller shaft from the front end of the engine drives the generator, the air compressor and the oil pressure pump, which, together with the radiator, the oil cooler and the heating equipment, are accessibly arranged at the front of the vehicle. The radiator fan is driven by a hydraulic motor, the speed of which is thermostatically controlled; it receives the pressure oil from a container, which also serves the hydraulic power steering. The layout of the front units and also that of the air suspension system with its level-control valves, is depicted in the two perspective illustrations on this page. Like most German heavy vehicles the bus is fitted with an engine exhaust brake; this brake is connected with the compressed-air service brake so that it no longer needs to be separately applied, but is operated automatically by the first stage of the foot-brake pedal valve. The bus is designed for a maximum speed of 43 m.p.h. and has a climbing capacity of 1 in 5·2 in bottom gear and 1 in 28 in top.

Adjustable driver's seat in noise-insulated cab of Magirus forward control truck

Henschel and Sohn showed a new 4·5-ton truck having a 90 h.p. four-cylinder underfloor engine and a synchronised five-speed gearbox with steering column control. The truck is designed mainly for short-distance operation, especially in towns and on narrow roads, and great attention has been paid to manœuvrability and ease of handling. In spite of the short wheelbase of 10ft and a total overall length of 19ft 2in the vehicle has the comparatively large floor space of about 92 square feet. The front wheels at full lock turn about an angle of 50 deg. giving the vehicle a turning circle of less than 40ft.

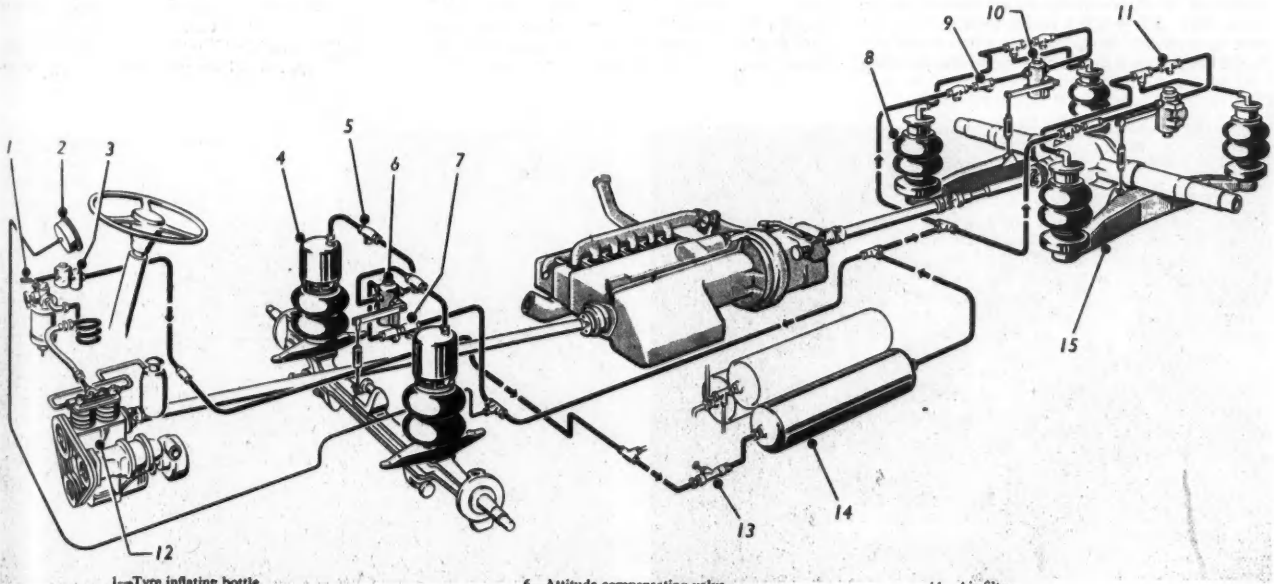
Apart from a bus in integral light metal construction with air suspension at the front and at the rear, Henschel also showed a forward-control tractor with an 8·5-litre, 145 h.p. engine which was equipped with air suspension at the rear only. The purpose of this construction is to provide a soft and adjustable springing at the rear in order to mitigate the pitching of the trailer irrespective of load variations. In this connection it should be mentioned that the layout of the Henschel air suspension differs from that of other firms in so far as the axles are not located by longitudinal and transverse rods, but by orthodox semi-elliptic leaf springs. According to their main purpose as locating elements the springs have two leaves only, and are dimensioned to take the static unladen weight of the car while the additional payload is carried by the air bellows.

Magirus, a company associated with Humbold-Deutz A.G., showed various items from its manufacturing programme, which includes trucks, buses, municipal vehicles and, in particular, fire-engines and fire-escapes. All these vehicles are equipped with Magirus-Deutz air-cooled engines ranging from an 85 h.p., four-cylinder to a 250 h.p. vee eight-cylinder engine. Among the various exhibits were several modified trucks and tractors and two entirely new all-wheel-drive vehicles, the latter equipped with 125 h.p. vee six-cylinder engines. A new city bus in integral light metal construction with a maximum carrying capacity of ninety-eight passengers was also powered by the six-cylinder engine, which, in




1—Fan.
2—Thermostatic fan control.
3—Air compressor.
4—Oil bath air filter.
5—Oil container (steering and fan).
6—Fan motor.
7—Generator
8—Dual pump.
9—Centrifugal governor (exhaust brake).
10—Cooling water pump.

**Front group of units of Mercedes-Benz Bus "O317"**




1—Tyre inflating bottle.
2—Dual-pressure gauge.
3—Air governor.
4—Air suspension.
5—Air filter.
6—Attitude compensating valve.
7—Air filter with non-return valve.
8—Air spring.
9—Air filter with non-return valve.
10—Attitude compensating valve.
11—Air filter.
12—Air compressor.
13—Overflow valve.
14—Air container (air spring).
15—Spring support.

**Air suspension diagram of Mercedes-Benz Bus "O317"**

this case, was mounted at the rear of the vehicle, together with a synchronised five-speed gearbox operated by remote electro-pneumatic control. The bus is further characterised by the combination of an independent front suspension with air bellows springing.

A similar design of air-sprung independent front suspension could be noticed on the latest buses of M.A.N. Apart from the already known coach types with rear-mounted 120 h.p. engines, the firm also showed a new city bus for 125 passengers with a 160 h.p. underfloor engine, obtainable either with a synchronised gearbox or with a Z.F. "Diwabus" automatic transmission.

Other examples of the same design tendencies were apparent at the stands of firms which specialise in the construction of bodies for goods and public service vehicles and build up complete vehicles, in particular buses, with the help of mechanical units bought from outside specialist firms. Krauss-Maffai A.G., for instance, showed buses with independent front suspension powered by rear-mounted Magirus engines and Büssing underfloor engines. Karl Kässbohrer G.m.b.H., a large firm of body-builders, also displayed a number of rear-engine buses of their "Setra" type, fitted with independent wheel suspension at the front and in one case with independent all-wheel suspension. At the Kässbohrer stand a new bus of stressed-skin light metal construction, with independent front suspension and air springing attracted much attention. The vehicle is powered by a rear-mounted air-cooled, 140 h.p., vee eight-cylinder engine of M.W.M., which is stated to be particularly silent, and is equipped with a synchronised eight-speed gearbox with electro-pneumatic control.

It is regretted that, in view of the numerous new designs in the field of buses and coaches, some interesting constructional details of goods vehicles, especially of tractors and tippers, could only be briefly noticed. We do not want to conclude this article, however, without mentioning at least the heaviest vehicle at the show, a six-wheeler with all-wheel drive, fitted with an all-steel, 23 cubic yard, end-tipping body. The vehicle, built by Carl Kælble G.m.b.H., for export or off-the-road service only, is powered by a turbo-charged 19-litre, vee eight-cylinder engine with an output of 300 h.p. at 1600 r.p.m. The torque is transmitted via a dry double-plate clutch and a five-speed gearbox to a distributor gear, and then to the axles, all of which have epicyclic hub reduction gearing. The vehicle unladen weighs 22 tons and can carry 30 tons.

# European Machine Tool Exhibition

No. III—(*Concluded from page 469, September 27*)

AN interesting production lathe equipped with a punched card control system which has been developed by Le Progrès Industriel, Loth, near Brussels (Soag Machine Tools, Ltd., London), is adaptable for small, medium or large batch production. The use of punched cards enables setting times to be reduced to a minimum, and the machine (Fig. 12) can be fitted with four independent detachable tooling units which can be operated in any required sequence. Each tooling unit on the turret, as it is indexed automatically engages a preselected spindle speed. The machine has a centre height of 11in, swings up to 24in over the bed, and the distance from the spindle nose to the turret face is 31in. Two ranges of twelve spindle speeds, from 18 to 600 r.p.m. and 54 to 1800 r.p.m., are available.

A hydraulic copying attachment fitted on the front of this lathe can be used in sequence with the turret tooling or in succession for a second operation when the workpiece has been reversed in the chuck. At the exhibition the machine was set for turning a large mushroom valve with a spigot on the opposite side of the head from the stem. For this job the turret tooling was first used to machine the spigot side; the valve was then turned round in the chuck and the profiling equipment used to machine the stem and face, the total turning time being nine minutes.

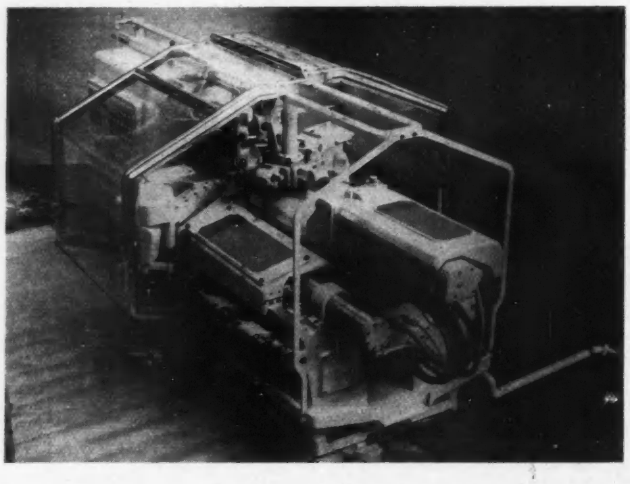
In order to provide ease of maintenance and maximum accessibility for inspection, unit construction has been adopted for a new hydraulic copying lathe by Edouard Dubeid and Co., Neuchâtel (Wickman, Ltd.). The principal units of this lathe are the base casting and main slide, the headstock and tailstock, spindle drive equipment, hydraulic equipment, and the electric panel. The complete hydraulic equipment, including the main reservoir, pump and valve block, is built into a drawer which slides into the front of the machine base. All the connections between this equipment and the machine units are made by flexible pipes so that the complete assembly can be drawn out for inspection without stopping production. The electric panel, in the form of a hinged cabinet, is situated at the right-hand end of the machine and can also be swung out whilst turning is in progress. In order to provide an even temperature throughout the machine to ensure consistent accuracy, a fan at the rear draws a constant flow of air through the cabinet base and bridge of the lathe. This machine is made in four models with different feed and speed ranges to swing 9½in diameter components and turn up to 4½in diameter between 20in centres.

A considerable amount of work has been in progress during recent years in the development of ceramic tools and the few machines shown in operation with these tools gave some indication of their potential for removing metal at speeds far in excess of those normal with the carbides. One firm which has built a lathe to take full advantage of ceramic tools is Max Mueller Brinker Maschinenfabrik, Hanover (K. S. Paul, Ltd., London), and the prototype machine, which has been built for Wickman, Ltd., was shown in operation. This "Eltromatic" lathe is of particularly rigid design and has a maximum spindle speed of 5000 r.p.m. It is stated to be capable of maintaining a constant cutting speed of 2400ft per minute and was to be seen cutting 65-ton nickel chrome molybdenum steel at 1900ft per minute with a 0·011in feed and 0·040in depth of cut.

The 30kW main drive of this lathe is effected by a thyratron-valve-controlled d.c. shunt motor which gives a steplessly variable speed range, and the spindle speeds can be set or varied automatically to enable turning with constant cutting speeds when facing. The carriage slides on hardened bedways and carries a platen cross slide which is 11in wide and has a cross travel of 15in. These lathes are being made in two sizes to swing up to just under 25in or 29in over the bed, and with different bed lengths to admit from 30in to 120in between centres.

Maschinenfabrik Ravensburg, Ravensburg (Württ.) (Mortimer Engineering Company, Ltd., London, N.W.10), showed the "KH.55" facing lathe, which we illustrate in Fig. 13. The machine has a sliding headstock to accommodate more elongated workpieces up to 31½in thick. A 1 : 4 "P.I.V." infinitely variable gear in conjunction with a twelve-step gearbox, is used to obtain constant cutting speed. The lathe is equipped with a "Unicop" electronic-hydraulic copying attachment. The hydraulic system is also used for normal turning, so that the change-over from copying to normal machining and vice versa can be made very rapidly. For access to the control valves the two-stage hydraulic pump and main valves are built into the saddle, the illustration showing the controls of the relief valves for the longitudinal and cross feed respectively. These valves adjust the circuit pressures, a larger pressure being necessary with a fine setting (for close limits) of the electro-magnetic valves operated by the tracer head, since the closer setting causes a greater pressure drop in the valve. Since the accuracy of the longitudinal and transverse copying can be set independently, a wide range of curvatures can be successfully copied. At the side of the saddle are mounted a number of adjustable stops. The headstock can be equipped with a main drive of 20 h.p., 27 h.p. or 33 h.p.

The "Model T.37" lathe of RAMO (Réalisations d'Appareils et de Machines-Outils, Niort)



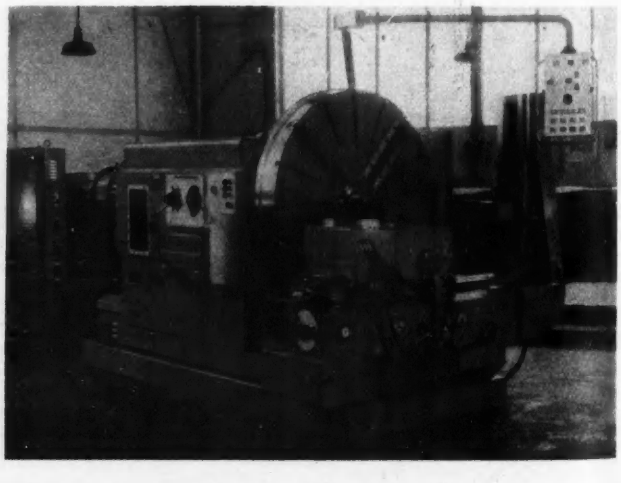


Fig. 12 (Left)—Production lathe with punch card control; the lathe is fitted with a turret and copying equipment—Progrès Industriel. Fig. 13 (Right)—Model "KH55" copying lathe—Maschinenfabrik Ravensburg

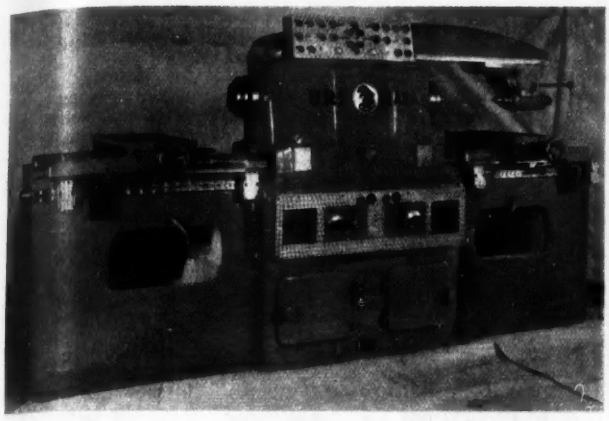


Fig. 14—" Ursomat " double-ended taper turning and copying lathe—Wilh. Beer

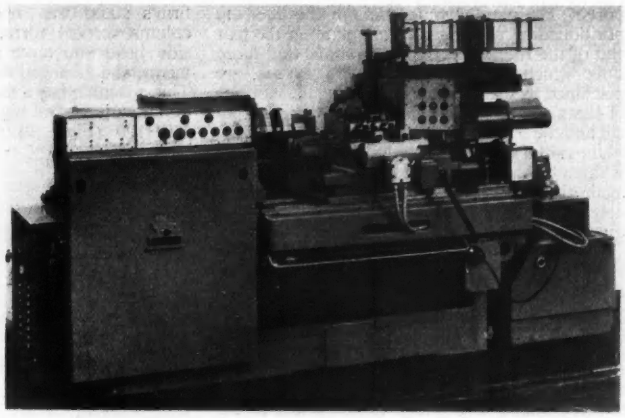


Fig. 15—" DP6 " automatic lathe with magazine feed and automatic checking device—Ludw. Loewe A.G.

is a universal machine built for maximum diameters over the bed of 370mm (178mm over cross slide) and distances between centres of up to 1000mm. Various ranges of headstock speeds up to 2500 r.p.m. and drives up to 8 h.p. are available. The chief interest of the lathe lies in the various systems of stops which have been incorporated. In the " Polybut " system adjustable screw end stops are carried on a rotatable drum and so can be brought into operation in turn to limit the travel of the cross slide, different drums being used for the front and back tool. The longitudinal travel of the saddle is limited by adjustable stops or a rotatable carrier mounted below the apron. Both devices, drum and carrier, can be removed from the lathes for setting. An accuracy of better than ±0·02mm is claimed. Diametral accuracy can be further increased to ±0·005mm by using the " Microbut " device on the cross slide spindle. This consists of a number of stops mounted on a short cylindrical column parallel with the slide spindle. The stops can be rotated individually and dropped into notches machined in corresponding rings on the drum of the cross slide spindle. These rings can be clamped in any desired angular position. The cutting tools are mounted in quick-change holders with adjustment of centre height by means of a knurled screw. By means of the " Regloutil " jig the tools can be preset to a high degree of accuracy, so that the time for changing a tool is reduced to a few seconds.

A high-speed automatic spline shaft milling machine, which was shown in operation by Carl Hurth, of Munich (Vaughan Associates, Ltd., London), is of particularly rigid construction with a single unit base and worktable. This worktable has a clamping area of 85in by 15in and the cutter slide is carried on broad ways at the rear. The working distance between the cutter spindle and the worktable is from 7in to 11in. The machine operates on the single indexing principle using a profile cutter which provides accuracy of profiles, particularly on shafts with multiple splines having straight-sided shanks.

When climb milling multiple spline shafts the cutter head is fed longitudinally along the machine and at the end of each traverse the cutter is lifted and the head returned under quick traverse. At the end of the return stroke the work is indexed and the cutting cycle repeated. Twelve spindle speeds from 90 to 1120 r.p.m. and twelve cutter head feeds from 2·46in to 31in per minute are available. Controls for the longitudinal feeds, rapid traverse and indexing movements are arranged in a cabinet at the left-hand end of the machine.

The machining of forged pinion shafts made of C45 steel by means of a fully automatic lathe which, after machining, checks the size of the workpiece, was shown by Ludw. Loewe and Co., A.G., Berlin, N.W.87. Our illustration (Fig. 15) shows this lathe, which is the model " DP6." The workpieces are taken from a drum magazine in which they are suspended, by an arm which by a 180 deg. rotation brings them into the lathe centre line. The pneumatic tailstock then moves the workpiece into the pneumatic chuck which grips it. After chucking the machine starts and the two supports move with quick approach speed to their cutting positions where the speed changes to the correct feed. In the particular job which was demonstrated, each support was equipped with three cutting tools which were engaged alone or together as required. On completing the machining, the tool supports are retracted and the arm again seizes the workpiece, which is released by the chuck and tailstock and transferred by the arm to a multi-point checking fixture, where it is checked by electric limit gauges. If it is within the tolerance limits it falls into a chute and slides into the outgoing tray. If the workpiece is outside the required tolerance, the automatic cycle is interrupted and the machine stops, while a light on a mimic panel in front of the latter indicates to the operator which tool requires his attention.

Photo-electric measurement of lengths and precision setting was shown as applied to a model " FBT 160/260 " horizontal boring mill made by Maschinenfabrik Froriep, Rheydt (Rhld). A mill equipped with these controls is depicted in Fig. 18. The control unit (Fig. 16) is in the form of a pendant and can be taken to any desired point at the machine. After preselecting the required dimension on the scales of the control unit, the operator waits for the preceding operation to be completed. On pressing a control button, the headstock or column of the machine automatically travels to the required position, using a quick approach and slow fine-setting movement. A special device allows the setting of dimensions whether given as chain dimensions or from a datum line, without the need for doing addition or subtraction sums.

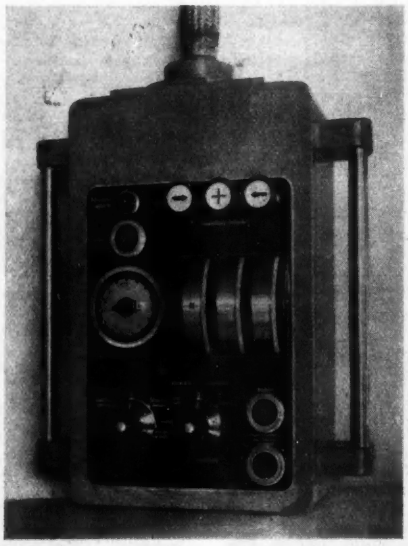


Fig. 16—Control unit for preselecting the setting of model "FBT 160/260" horizontal boring mill—Froriep

The machine tool bed is provided with a scale divided into lengths of 500mm, while the column carries a subsidiary scale for the intermediate values. The bed scale consists of a number of apertures set at distances of 500mm with an accuracy of ±0·002mm, while the subsidiary scale is formed by a lead screw which carries a saddle fitted with a photo-electric device, which can be moved with an accuracy of ±0·005mm. This photocell controls the movement of the column, the displacement being transmitted to the control unit. For vertical movements the coarse scale is fitted to the column and the fine scale to the headstock of the mill. The setting of each dimension is carried out in three stages.

If one wishes to establish the position of the column at any given moment, the control unit is set to position " O." The indicator scales then turn in synchronism with the moments of the photo-electric system on the saddle. When they have come to rest they are set to zero by hand. A datum position for subsequent settings having thus been established, the desired dimension can then be set to the nearest 0·01mm. It is stated that the reproducible accuracy of a setting is ±0·005mm irrespective of the size of the dimension or the direction from which it is being approached.

The group of machines shown by Th. Kieserling and Albrecht of Solingen (F. W. Kubach, London), included the firm's latest design of combined centreless bar peeling and turning machines for bars from 0·59in to 3·15in diameter. This machine has three adjoining heads for rough and finish turning and roll polishing of bars and is fitted with automatic loading and unloading equipment. A new horizontal forging machine made by this firm is made in a range of sizes with upsetting pressures from 125 to 2000 tons. The horizontal arrangement of the gripping jaws allows upsetting operations on small forging blanks without grip ends.

A prominent exhibit of the Asquith Machine Tool Corporation, Ltd., was the " H.R.G." horizontal drilling, boring and milling machine shown in Fig. 17. This machine is of the firm's standard design, but is fitted with electronic control, and in the illustration is profile milling the ports in a Doxford engine cylinder liner. For this work it is used in conjunction with a rotary headstock and a tailstock mounted on a workplate.

The horizontal traverse of the column along the bed is controlled by two motors, the first motor being mounted on the slide for quick power traverse, and the second mounted on the column base for electronic feed, these electronic feeds being in addition to the normal mechanical feeds which are supplied for movement in this direction. The motions are interlocked so that only one can be brought into operation and a clutch is interposed in the feed system to select either feed or quick power traverse motion.

A bracket, at the side of the slide and in line with the spindle, carries a stylus roller, which contacts the template mounted upon the liner itself and provides the necessary form for the milling of the

ports. The parallel water slots in the liner are positioned by use of a dividing plate on the rear end of the rotating headstock spindle, and those slots which are interrupted by bosses are machined by the operator controlling the motions of the machine in accordance with the depth of cut and the traverse which is required. Machining of the radial slots which are interrupted by bosses is done by the feed of the rotary headstock and again the operator controls the traverse which is necessary for the slots up to the bosses in question.

For positioning the cutter and stylus for the various port holes a vertical rod carries a special rule on which slides a vernier and magnifying glass which are attached to the slide. When the machine spindle is in line with the headstock centre line the vernier is positioned at zero, so that the amount the cutter requires to be offset to the component can be readily achieved by either upwards or downwards movement of the slide with reference to the rule. A snout attachment bolted to the facing around the spindle on the slide of the machine gives support to the spindle when drilling and milling in an extended position.

The headstock which carries the cylinder liner at one end provides quick rotation for setting purposes at the rate of 1 r.p.m. by a motor drive, and slow rotation for feed is provided to the headstock by a second motor giving a rate of 1in to 6in per minute at 3ft diameter with equal slip gears. Various slip gears are provided to ensure that the peripheral speed of the face plate is correct for the various diameters of cylinders which are to be accommodated.

Amongst the heaviest and largest machine tools exhibited were a 4 K500 double column vertical boring mill and an FB 32/19 horizontal milling and boring machine on the stand of Schiess A.G., Düsseldorf (Burton, Griffiths and Co., Ltd., Birmingham). The vertical boring mill has a 16ft 5in diameter worktable to take a maximum load of 45 tons, the maximum turning height being 11ft 6in. The milling and boring machine has a 14ft vertical travel of the saddle and a horizontal column travel of 32ft 6in. Its milling spindle is 12¾in diameter and the boring spindle 7½in diameter: the machine is designed to bore up to 55in and face up to 87in diameter. A smaller machine of interest on this firm's stand was one of the KE100 single column vertical turret lathes equipped with a side head and taper and screw-cutting attachments, and arranged for automatic speed control. This machine has a maximum turning diameter of 45in up to 43in high and with it there was a KEH100 (Fig. 19) with an electro-hydraulic control system for an automatic work cycle.

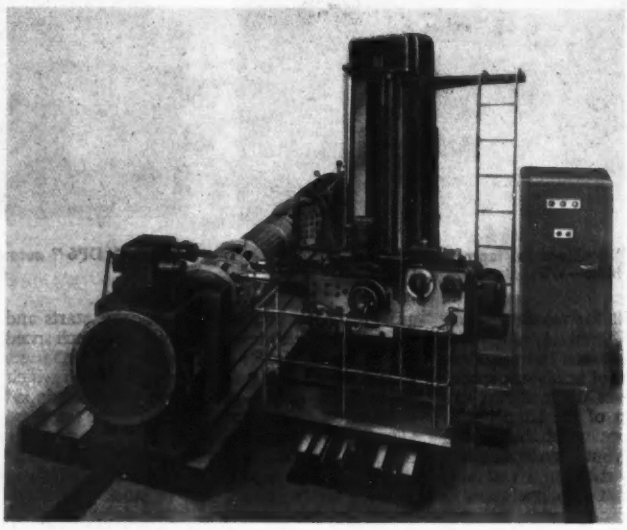


Fig. 17—Drilling, boring and milling machine with electronic control—Asquith

The automatic movements of this machine, which are controlled through cams, can be in any required sequence, and during the sequence all movements of the turret, saddle and side head and the feeds and speeds are interdependent. Selector switches are used for initial setting purposes, and the vertical and horizontal longitudinal movements are controlled by trip dogs adjustable along slides. In the control panel for the rail head slide and ram there are three selector switches for each of the five positions of the turret head. One switch is for preselection of the table speed, one for the steplessly variable feed and the third has eleven positions for the various sequence control combinations. The control panel is further provided with a four-position switch for table speed setting and a switch for individual control in each of the five turret positions. The machine can be provided with hydraulic chucking, thread cutting, taper turning, and hydraulic copying attachments, if required.

Our illustration (Fig. 14) shows the "Ursomat" taper turning and copying double lathe, which has a maximum swing of 320mm and a length between centres of 500mm. Each headstock has speeds of 230 to 3025 r.p.m. and is powered by a 5 h.p. or 6 h.p. pole-changing motor. The feeds are also independently powered by 0·56 h.p. or 0·75 h.p. motors. It is stated that the design eliminates the error which is liable to occur when two components are taper turned on separate machines. On the "Ursomat" the taper is produced by swivelling the double headstock together with the tailstock arm by the amount required. Either one tailstock, or two, can be fitted. By using two copying attachments copy machining can be carried out at both ends. Complete machining cycles with several cuts can be carried out in this way fully automatically. The machine is manufactured by Wilh. Beer Spezial-Werkstätten, Wiesbaden (Germany) (Rockwell Machine Tool Company, Ltd., London).

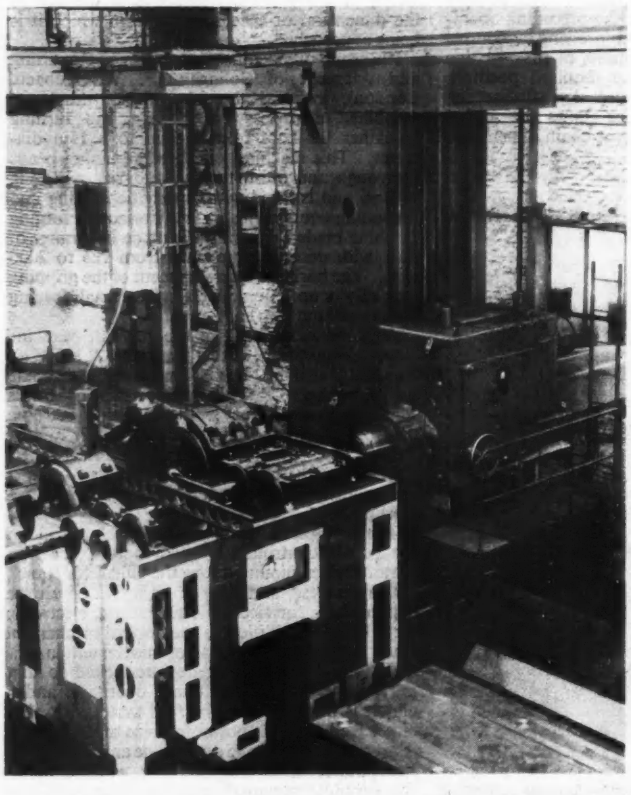


Fig. 18—Horizontal boring machine, Model "FBT 160/260"—Froriep

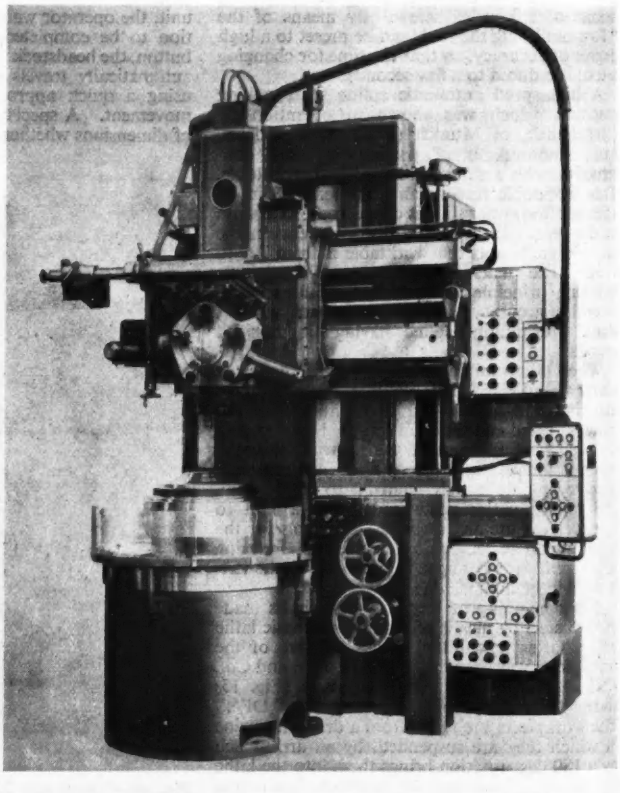


Fig. 19—Single-column vertical turret lathe with automatic work cycle—Schiess

# Dresden Nuclear Power Station in Illinois

BY OUR AMERICAN EDITOR

( No. II—*Concluded from page 473, September 27*)

*On June 12 last major construction commenced on the Dresden nuclear power station of the Commonwealth Edison Company near Chicago, Illinois. A 190ft sphere will house a General Electric dual-cycle boiling water reactor and a turbo-generator. At present the 180MW plant is the largest all-nuclear power station under construction in the United States, and it is expected to be completed by 1960. The reactor fuel to be used is a slightly enriched uranium dioxide fabricated as a sintered solid in the form of a cylindrical pellet.*

## Core Design

THE basic objective of the core design is to achieve low fuel cost with a high degree of reliability, safety and plant availability. At the same time the core must withstand the mechanical, hydraulic and thermal conditions resulting from both steady state, transient and emergency operation. The reactor core is supported inside the reactor vessel. The core assembly consists of an array of cylindrical fuel elements held by means of a bottom support plate and top-grid alignment structure. The physical arrangement of the core, the reactor vessel and the control rods is shown in Fig. 8. The basic design and performance data of the core assembly and fuel elements are given in an accompanying table.

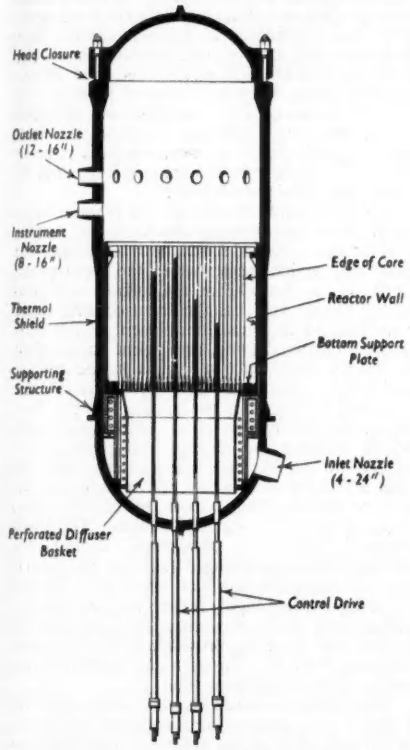



**Fig. 8—Sectional view of the reactor vessel, core and control rods**

The reactor core is a honeycomb structure of square "Zircaloy-2" channels, approximately 3¾in on the side. Each channel which does not contain a control rod has twenty-five round fuel rods, of approximately ½in diameter, arranged in a square lattice. The channels that have control rods contain sixteen fuel rods and nine rods displaced by the poison-type control rod. The basic fuel is slightly enriched uranium dioxide fabricated as a sintered solid and in the form of a cylindrical pellet. A series of these pellets are encased in a "Zircaloy-2" tubular jacket to form a rod. As shown in Fig. 9, all fuel rods terminate in a common base support, situated at the lower end of the assembly. This base forms a holder for orifice assemblies and acts as a tie-bolt for connection with the associated channel piece. Since the fuel rods are rigidly attached to a common member at the base support piece, the fuel rods support their weight in compression. All thermal expansion movement is directed upward in relation to the channel section. Provision is made for the relative expansion between fuel rods by spring-loaded head pieces at the upper and lower ends of the rod bundle. Intermediate spacer plates are sufficiently flexible to allow a modest relative expansion without excessive distortion.

*Particulars of Core Assembly in Dresden Boiling Water Reactor*

| | |
|---|---|
| Main dimensions and quantities : | |
| Diameter (Max. O.D.) | 10·5ft |
| Height (channel sub-assembly) | 10ft |
| Fuel element geometry | Cylindrical rods in square array |
| Rod spacing (centres) | ¾in |
| Sub-assembly channel (square) | 3¾in, outside |
| Fuel rods, normal sub-assembly | 25 |
| Fuel rods, control rod sub-assembly | 16 |
| Total sub-assemblies in reactor | 700 |
| Fuel rods in reactor | 17,000 |
| Water volume to $UO_2$ volume | 2 : 1 |
| Fuel : | |
| Rod construction | $UO_2$ pellets within zirconium jacket |
| Total rod length | 112in |
| Total active rod length | 104in |
| Rod diameter | ½in |
| U in reactor | 60 short tons |
| Enrichment (probable at 5000MW-days per ton irradiation) | 1·5 per cent U235 |
| Irradiation time (70 per cent operation—10,000MW-days per ton) | 4·0 years/core |
| Refuelling schedule | 6 months |
| U total throughput (70 per cent operation) | 32,000 lb per year |
| Irradiated fuel storage capacity | 120 per cent reactor load |
| Heat transfer and fluid flow (at rated load) : | |
| Average heat flux | 100,000 B.Th.U. per hour-square foot |
| Maximum heat flux (hot spots) | 300,000 B.Th.U. per hour-square foot |
| Average power density (in core coolant volume) | 1500kW per cubic foot |
| Maximum fuel temperature (centre) | 2800 deg. Fah. |
| Inlet velocity (centre channel) | 5ft per second |
| Sub-cooling | 51·4 B.Th.U. per pound |
| Exit water velocity (centre channel) | 10ft per second |
| Steam quality (by weight at outlet) | 4·92 per cent |
| Exit steam quality (by volume in centre channel) | 47 per cent |

Lifting bails are provided at the upper end of each fuel bundle assembly for handling and charging functions. These bails are attached directly to a pair of fuel rods through which the assembly is carried. Provision is made for the performance of refuelling and maintenance operations on a routine basis. Adequate clearances are provided throughout the core structure to allow for handling without galling or distortion. Supporting structures within the core assembly are of sufficient strength to permit minor mis-alignment of fuel bundle assemblies during refuelling operations. The entry points and guide surfaces are tapered and faired to facilitate the positioning of fuel bundle assemblies during refuelling.

To satisfy the nuclear requirements, the lattice of fuel rods has approximately a 2 : 1 water-to-uranium ratio. Special nuclear considerations arise when operating with boiling in the core as the steam bubbles decrease the reactivity due to under-moderation and increase leakage. This characteristic causes the flux distribution to shift from a cosine shape, being skewed toward the non-boiling or bottom part of the core. The axial shifting of the heat flux can be reduced by one or more of the following remedies : (*a*) by variation in axial enrichment ; (*b*) by control rods being inserted into the non-boiling region, and (*c*) by varying the fuel density along the axis. A radial flux distribution also exists, which shows much lower flux values at the outside of the core than at the centre. This effect is caused by neutron leakage from the core.

The overall peak-to-average flux ratio is approximately 2·5 and allowance for local hot spots increases this value. The initial conversion ratio is approximately 0·6. As discussed above, the enrichment is varied axially through the core. The average is approximately 1·5 per cent, which gives a total of approximately 800 kg of U235 with fresh fuel. Sufficient enrichment is included to provide the additional reactivity required to balance losses caused by temperature effect, bubble formation, xenon and samarium poisoning and the reactivity loss between loadings.

The complete establishment of the heat transfer, hydraulic and thermodynamic operating conditions was determined by balancing the heat rate, optimum physics performance of the core, plant stability and reliability and mechanical design considerations. These requirements are sometimes incompatible. For instance, an improved heat rate results from an increase in the primary-to-secondary steam ratio, but such an increase results in a higher fraction of steam voids in the core, thereby making considerations of burn-out and nuclear stability of paramount importance. Also, the best heat rate does not necessarily produce minimum fuel cost. Enrichment of the fuel to reach a good exposure is a major factor of fuel cost, and is governed by the nuclear conversion ratio and reactivity which are a function of the void distribution in the core.

Average conditions of operation are not sufficient to specify the overall dimensions of the core as allowance must be made for the performance of the worst channel. There are a number of factors which cause deviation from the average channel power calculated by dividing the number of channels into total power. Some of these factors are the variation of flux, axially and radially ; the variation of heat transfer coefficients ; the differences between fresh and exposed fuel ; the local effect of control rods ; the non-uniformity of enrichment ; and the flux perturbations caused by control rod withdrawal. All of these factors led to the selection of about 17,000 ½in fuel rods, each ½in diameter. The number of flow channels required, considering the fuel rods displaced by control rods and instruments, is approximately 700. The optimum fuel rod diameter was set by economic studies

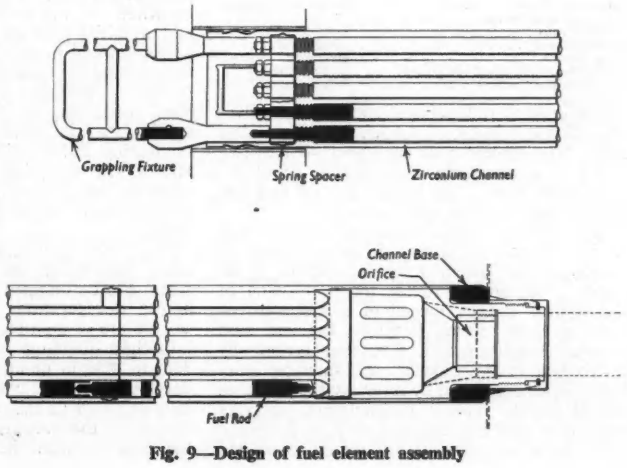



**Fig. 9—Design of fuel element assembly**

considering zirconium material and fabrication costs, fuel inventory charge, cost of plant down-time and allowable heat fluxes and control rod temperatures.

### Reactor Vessel Design

The reactor vessel is shown in Fig. 8, and its principal data are tabulated here :

| | |
|---|---|
| Diameter (I.D.) | 12ft |
| Height (inside) | 40ft |
| Shell material | A.S.T.M. A-302 steel |
| Shell thickness opposite core | 5½in |
| Clad material | A.I.S.I. 304 L stainless steel |
| Total weight | 350 short tons |
| Inside diameter of heat closure | 11½ft |

The vessel contains and supports the core assembly mounted on top of the core support ring. Access for refuelling, changing control rods and servicing of instrumentation is made through a single head closure at the top of the vessel, whereby the complete core and control assemblies can be removed if required. Cooling water enters the vessel through four 24in inlets and the steam-water mixture leaves through twelve 16in outlets near the top of the vessel. Additional penetrations through the vessel wall are provided for thermocouples, flux monitoring devices, fuel rupture detection, pressure taps, drains and poison injection.

The optimum fuel performance determined the diameter of the fuel rods and the water-to-fuel ratio. Heat transfer and physics considerations established the required core area for heat transfer. In meeting these requirements, a balance between core diameter and length was made. For the output of 627MW, the optimum vessel diameter approaches the maximum size that it is feasible to fabricate. It may be possible to build a still larger vessel, but considerations such as the size of forgings and transport then become major problems. The disadvantages of reducing the diameter by increasing the vessel length are the increased control stroke, the increased clearance distance for fuel handling and the less significant factors of increased pressure drop and increased neutron leakage. The design is based on the requirement that the visual handling of fuel bundles under water be done on a routine basis. Since no proven seal is available at diameters above about 6ft 6in, a development programme is now in progress.

### Control Rod System

The inherent self-regulation of the dual-cycle boiling water reactor does not eliminate the necessity for a control rod system. The principal functions of the control rod system are : to provide control of the reactor when control by steam void formation is not available, i.e. during start-up or shut-down ; to provide a system of rapid shut-down (scram) ; to provide a means of controlling the neutron flux distribution in the core ; to regulate the ratio of primary steam to secondary steam ; and to compensate for long-term reactivity changes in the core due to burn-up and fission product poisoning. The control rod system consists of approximately ninety control rods situated in an 8ft 6in diameter cylinder centred in the core. Pertinent control rod data are tabulated here :

| | |
|---|---|
| Total control strength required | 14·5—17·5 per cent |
| Total number of rods | 90 |
| Length of rods | 9·5ft |
| Drive (normal) | Mechanical |
| Drive (scram) | Hydraulic |
| Average velocity (normal operation) | ¼ft per second |
| Average velocity (scram) | 10ft per second |

The control rod poison is a cadmium-silver alloy clad in a jacket of A.I.S.I. " 347 " stainless steel. The control rods are about 9ft 6in long and have a cruciform cross section about 3in wide by ¼in thick. The cross is centred in a fuel channel and displaces nine fuel rods.

The position of each control rod is controlled by individual control rod drives contained in thimbles which extend from the bottom of the vessel. The drives provide for positioning of the control rod by means of a motor-driven screw actuator which positions the end stop of a double-acting piston. The piston is normally pressurised to push against this movable stop. Scram is accomplished by reversing the pressures on the piston. Twelve accumulators supplying seven rods each are used to supply the hydraulic power for scram. The motor drive and associated control allow operation of only one control rod at a time, and at a normal rate of 6in of rod travel per second. During scram, all the control rods, up to a total of forty-three which are out of the core, can be rapidly inserted. The maximum time for insertion is approximately 1·5 seconds.

In addition to the control rod shut-down, a liquid poison back-up system is also provided. This system consists of an accumulator reservoir which contains 50 cubic feet of sodium pentaborate poison solution. A schematic diagram of this back-up system is shown in Fig. 10. The

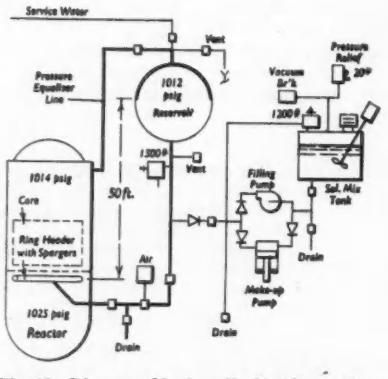



**Fig. 10—Diagram of back-up liquid poison system**

reservoir is situated above the core support plate to provide the necessary head for injecting the poison into the system. All lines and equipment which hold the poison solution are steam-heated to prevent crystallisation of the solution.

### Design of Turbine

As indicated in Fig. 2 (*ante*), the saturated primary and secondary steam enter the dual admission turbine from the steam mains which connect the reactor plant to the turbine. The exhaust from the turbine is condensed and pumped through the air ejectors and the gland seal condensers. The condensate then divides into two flow paths—one through the secondary feed pumps and the secondary stream feed-water heaters to the secondary steam generators and the other through a condensate demineraliser, the primary feed pumps and the primary stream feed-water heaters to the reactor. Five separate heaters are used on the primary and secondary feeds, giving a total of ten vertical heaters. Integral drain coolers are used in the three top heaters of the primary circuit and external drain coolers are used with the two lower heaters.

The turbo-generator set consists of high-pressure, intermediate pressure and low-pressure sections exhausting into a common condenser opening. The flow path through the turbine is shown in Fig. 2. The three turbine sections are on one shaft connected to one 1800 r.p.m., 245,000kVA generator. The turbine is provided with moisture separating devices at each extraction point, at the crossover, and at the last stage of the high and intermediate pressure sections. The unit has a load control governor on the secondary admission valves and an initial pressure governor on the primary admission and by-pass valves for by-passing the flow around the turbine to the condenser. The turbine is provided with seals for sealing the shaft when on the turning gear so that the turbine may be filled with water and decontaminating fluids prior to maintenance operations. In designing the turbines, particular attention was given to the elimination of pockets or crevices in which radioactive material may lodge.

The turbine by-pass valves provide a safety relief system for the reactor, through which steam can be dumped through reducing orifices and a desuperheater to the condenser. The orifices are of multiple plate design and exhaust into eight discharge pipes ranging in size from 30in to 42in in diameter. A method has been developed with the condenser manufacturers for exhausting about half of the by-passed steam into the side of the condenser and the other half into the neck between the turbine and condenser. This design eliminates having an abnormally high turbine foundation. Failure of the by-pass valves or closure of the sphere isolation valves brings into operation another full set of safety valves. They are connected to the primary system and are inside the sphere. The condenser is also protected by relief diaphragms which exhaust above the roof of the turbine building.

There is a possibility of oxygen being produced by dissociation in the reactor. Therefore the condenser and its air removal apparatus are sized to handle abnormal quantities of non-condensible gases. Provision is made in the air removal line from the condenser to hold up the gas a minimum of three minutes to provide decay time for radioactive gases which may be present.

### Ancillary Plant

The control of water purity in the primary circulating system of the boiling water reactor is highly important in the operation of this plant. The total allowable solids contents in parts per million are comparable to those maintained in other water reactor systems, but are far below acceptable concentrations for conventional power stations. Furthermore, the total solids in the boiler of a conventional plant are reduced by blowdown. Because of contamination of the reactor water with radioactive materials, a clean-up system is provided to maintain the desired purity. Reactor water circulates through a clean-up loop consisting of a regenerative heat exchanger, a non-regenerative heat exchanger and a mixed bed demineraliser. The demineralised effluent is then returned to the primary steam drum by means of a pump. A resin bed removes both suspended and dissolved solids, retaining these impurities in the bed. After the resin bed is spent provision is made to remove the resin from the demineraliser tank by sluicing to a resin waste burial pit.

The total solids content in the reactor water result from corrosion products in the reactor circulating system and solids, both suspended and dissolved, which enter with the feed-water. Corrosion products from the turbine and condenser system and leakage from cooling water contribute to the impurities present in the feed-water. Demineralising equipment is supplied to remove these trace materials in the reactor feed-water. The full feed-water flow to the reactor is 3100 gallons per minute and this flow passes through two of three demineraliser beds before entering the reactor feed pump. The condensate entering the demineraliser system contains a fraction of one part per million of solids and the demineralisers reduce this concentration to about four parts per 1000 million. The solids removed from the condensate should not normally be radioactive and therefore provision is made for the regeneration of these resins. Should the resins become highly radioactive because of a fuel element failure and subsequent carry-over of high-activity material, provision is made to flush the resins from the demineralisers directly to the radioactive resin storage vault.

The radioactive waste disposal system provides a means for removing and disposing or storing of all radioactive liquid and solid waste material from the entire plant. The system is operable at all times whether the plant is operating or shut down. The main sources of the radioactive impurities include corrosion products from the primary and secondary steam system, poison material used in the back-up safety system, corrosion and fission products from new and spent fuel and fluids and other materials used in the decontamination of equipment.

Wastes are handled in one of several ways. The method used in any instance is determined by the kind of waste, level of radioactivity and contamination. The batch process method is used. Liquid wastes are either discharged to the river under controlled conditions, filtered and demineralised and returned to the make-up system, or stored to permit radioactive decay. In the case of acid or detergent wastes a special tank equipped with an evaporator is provided to concentrate the liquid for ultimate storage. This equipment is also available for other waste fluids. Permanent storage is provided for the disposal of solid wastes, including resins from various demineraliser systems, corrosion pro-

ducts and airborne dust trapped by some of the open systems, such as the fuel storage basin. Contaminated resins and filter material from the three systems using demineralisers are hydraulically sluiced to permanent waste resin storage as the need arises. Interconnections are provided between the reactor clean-up system and the waste disposal system.

### Fuel Handling System

The principal requirements of the fuel handling arrangements include : (*a*) the provision for removal and replacement of all of the components of the reactor core, (*b*) the provision for the dismantling of the irradiated fuel channels and bundles in order to be able to re-use the expensive zirconium channels, (*c*) the provision for the return of discharge fuel to the reactor, and (*d*) the provision for refuelling during a week-end shut-down. Approximately 20 per cent of the total number of fuel bundles are to be refuelled during the normal refuelling period of six months. Each bundle weighs approximately 250 lb, and the total weight of fuel handled during a refuelling operation is about 16 tons.

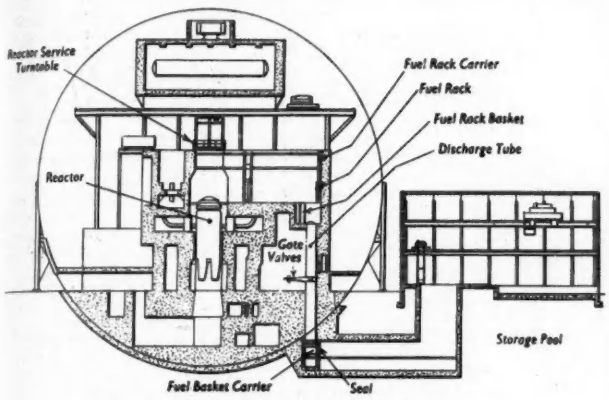



**Fig. 11—Sectional view of fuel handling system**

The fuel handling system is illustrated in Fig. 11 and is most easily explained by reviewing the method of operation. After cooling the reactor to a temperature of approximately 120 deg. Fah., the vessel lid is removed and the discharge canal inside the sphere is filled with water. The operator removes one fuel element at a time from the reactor core by means of the cranes on the reactor service turntable and places it into the empty space in the fuel rack. The fuel element is kept under water at all times to protect the operator from radiation. A new element from the second position on the fuel rack is placed into the empty hole in the reactor, and a second used element is removed from the reactor. This is continued until the rack is completely filled with irradiated fuel elements. The rack containing irradiated fuel is then sent around the periphery of the canal and a second rack of fresh fuel, which has been loaded on a second carrier, is brought into position underneath the turntable.

While reactor reloading is being done from the second rack a second operator replaces the first rack of irradiated fuel into the fuel rack basket and puts a new rack on another carrier. The operations are repeated until the basket is completely full of racks containing irradiated fuel. The basket of irradiated fuel is lowered through the discharge tube into the fuel basket carrier. After the basket has been lowered into the fuel basket carrier the crane hook is withdrawn and the valves are closed. The fuel basket carrier is then moved horizontally through the canal to a position in the fuel storage building. In the pool in the fuel storage building the fuel rack basket is removed from the fuel basket carrier, and a second basket of new fuel is placed into the carrier and sent back into the sphere. These two basket loads provide for enough fuel bundles to reload the reactor of the normal 20 per cent reloading.

### Start-Up and Shut-Down Procedure

Start-up procedures vary depending on initial plant conditions at the time of start-up. After an extended shut-down the plant is started from cold conditions as follows. Starting with water in the primary drum, the system at approximately atmospheric pressure, and with reduced recirculation flow, the reactor is brought to critical and power is adjusted to the value that maintains a specified temperature rise. At this time the reactor system valves are closed. As the water is heated the vapour release in the primary steam drum maintains saturation pressure in the drum. Thus the system pressure increases with temperature but without boiling in the reactor. At a pressure of about 150 lb per square inch gauge the reactor pressure regulator comes into operation. Power is then increased until boiling is established in the reactor core and the reactor steam flow is sufficient for turbine start-up.

At this point steam is being by-passed to the main condenser through the turbine by-pass valves. Turbine start-up can then begin while the reactor system temperature and pressure continues to be increased. The system temperature rise is now controlled by readjustment of the pressure regulator setting rather than by adjusting the control rods. A gradual opening of the turbine primary admission control valves results in the diversion of flow from the turbine by-pass valves, thus imposing no transients on the reactor. The plant is now operating on a constant void reactivity characteristic in a normal manner. The turbo-generator is brought up to speed, synchronised and loaded. The reactor pressure is still somewhat below its rated value ; however, approximately 5 to 10 per cent load may be supplied. When the rated system pressure is reached the remaining secondary steam generators are put into service and the unit load increased to meet system requirements. If full load is required, the control rods are adjusted to establish rated void reactivity and rated primary steam flow. For short shut-downs the reactor will normally be maintained at rated temperature, resulting in a simplified start-up procedure, requiring considerably less time. A cold start-up is estimated to require approximately five hours from a cold condition to full load.

A normal plant shut-down of short duration is accomplished while maintaining system pressure. The reactor decay heat is accommodated by the pressure regulator in a normal manner. The turbine can be removed from the line in any way that the operator chooses, and the reactor steaming rate is reduced by the manipulation of the reactor control rods. Normal plant shut-downs of long duration (when refuelling, for example) are done in a similar way. However, the system pressure is reduced by progressive readjustment of the pressure regulator setting, to ensure controlled cooling within a reasonable time. After the turbine is removed from the line steam is by-passed to the main condenser until the rate of decay heat is sufficiently low to be removed by the unloading heat exchanger system. At this point they are put into service.

The plant is designed to accommodate emergency shut-downs such as complete loss of generator lead or turbine trip-out without scramming. In this event, reactor power is rapidly reduced to 40 per cent by the self-regulating characteristics of the core, and primary steam is by-passed to the condenser. If for any reason the condenser is not available, the reactor is scrammed and reactor steam is condensed in the emergency cooling system. To ensure complete reactor enclosure in the event of an incident or potential incident, sphere penetrations that are open during normal operation are automatically closed. The primary and secondary steam sphere isolation valves are designed to close automatically by the following signals :—(*a*) high pressure in the sphere, (*b*) high pressure in the main condenser, and (*c*) low water level in the primary drum. The ventilation duct sphere penetrations are designed to close automatically by all scram signals.

### Electrical Plant

Power will be generated at 14·4kV by an 1800 r.p.m. conventional hydrogen-cooled generator having a rating of 245,500kVA at 0·85 power factor, and a short circuit ratio of 0·64. The machine is directly connected to a 225,000kVA main power transformer and a station auxiliary transformer by a self-cooled isolated-phase bus-bar. The main transformer is situated next to the turbo-generator building and steps up the voltage to 138kV for integration into the Commonwealth Edison grid system. The station auxiliary load is normally divided between two auxiliary power transformers, which are fed from the generator and the 138kV bus. Both transformers can supply power to two 4160V bus sections. These two bus sections may be connected to the third bus section which has available for plant shut-down protection a 1000kW diesel-generator unit. This unit and the third bus section are physically separated from the two 4160V bus sections. This dispersion, together with the separation of the 480V load centre, reduces the probability of a single incident rendering the auxiliary system incapable of powering essential loads. All essential shut-down and post-incident loads are served by the 480V system. One transformer to each of the 480V load centre is directly connected to the third bus, which is fed by the diesel-generator in case of loss of station power.

## British Floodlighting System for Niagara Falls

A new colour-floodlighting system of British design is to replace the existing floodlight installation at Niagara Falls. The work will be carried out under a 153,000 dollar contract awarded by Niagara Falls Illumination Board to the Amalgamated Electric Corporation, Ltd., a Canadian subsidiary of The General Electric Company, Ltd., Kingsway, London, W.C.2. The floodlights will be mounted on the Rotunda in the Queen Victoria Park. Ten projectors will illuminate the 2600ft wide Canadian Horseshoe Falls, 1700ft away ; three more will be directed towards the Upper Rapids, two will light the rock face at the base of Goat Island joining the two falls, and five will illuminate the American Falls, 3000ft away. Without any increase of power consumption, the new floodlight projectors will, it is stated, give at least four times the brightness of the twenty-four floodlights which they will replace.

The G.E.C. floodlighting system was explained to representatives of the Niagara Parks Commission in Canada on a tape recording made at the company's research laboratories and flown to Canada to support a more detailed technical specification. Later, representatives of the Niagara Parks Commission attended a large-scale working demonstration at Stanmore, Middlesex, where a prototype projector was arranged to illuminate a simulation of Niagara Falls produced by smoke bombs and cascades of water from hoses of the company's fire brigades.

In the installation at Niagara Falls twenty specially-designed weatherproofed high-current-density carbon-arc projectors incorporating remotely-controlled automatic colour-changing devices and wide-beam arrangements will be used to give a large range of dramatic lighting effects. The projectors, to be supplied under sub-contract by Savage and Parsons, Ltd., of Watford, will have a forced ventilation system provided by a high-speed motor-driven blower with a non-return valve fitted in the housing of the lamp to allow for the positive air pressure in the housing without admitting spray from the Falls.

The optical system consists of a paraboloidal silvered glass reflector approximately 36in in diameter with a focal length of 42cm. The crater brightness of the arc will be about 18,000 candelas per square centimetre, giving a beam intensity of 210 million candelas. Attached to the front of each projector is a housing which provides automatic colour changes by a series of five 37in square colour filters held in metal frames.

# Personal and Business

## Appointments

MR. L. E. P. TYLOR has joined the board of Ruston-Bucyrus, Ltd.

SIR ROY DOBSON has been elected deputy chairman of the Brush Group, Ltd.

MR. R. A. WEST, A.M.I.E.E., has been appointed a director of Contactor Switchgear, Ltd.

MR. E. J. TURNER has been appointed secretary of the Central Electricity Generating Board.

LIEUT.-COLONEL C. P. DAWNAY has been appointed a director of Electric and Musical Industries, Ltd.

COMMANDER MICHAEL B. St. JOHN, R.N. (ret.), has been appointed managing director of Liquid Systems, Ltd.

PRIOR STOKERS, Ltd., has announced the appointment of Mr. J. Hall as technical representative for the East Midlands area.

MR. A. M. TAYLOR, secretary and commercial manager of Foster Transformers, Ltd., has been appointed a director of the company.

MR. A. J. SPEAKMAN has been appointed work study manager in the operational research and cybernetics department of the United Steel Companies, Ltd.

MR. R. W. WHINERAY has been appointed vice-chairman of Francis Morton and Co., Ltd., in succession to Mr. H. W. Darbishire, who has retired from the board.

MR. DAVID MCINTOSH has been appointed manager of product planning and Mr. H. D. Frymire manager of domestic sales of the International Harvester Company of Great Britain, Ltd.

D. NAPIER AND SON, Ltd., has announced the appointment of Mr. J. C. L. Southam as deputy commercial manager (diesel). Mr. J. H. Barker has succeeded Mr. Southam as sales manager, turbo blowers.

MR. JAMES BOYLES has been appointed director and general manager of Beldam Asbestos Packing, Ltd., Toronto, Canada, in succession to Mr. J. G. Cheesman, who has retired after thirty-one years' service with the company.

THE BRITISH SHIPBUILDING RESEARCH ASSOCIATION has announced that Sir James McNeill has been elected chairman of council in succession to Sir Charles Connell, and Mr. J. A. Milne has been elected vice-chairman in succession to Sir James McNeill.

STEEL, PEECH AND TOZER, branch of the United Steel Companies, Ltd., announces the following appointments :—Mr. J. Taylor, sales manager, hot strip rolling mills ; Mr. I. Mulhearn, sales manager, cold strip rolling mills ; and Mr. P. Sherwell, manager, central sales office.

GOODWIN BARSBY AND CO., Ltd., states that Mr. Frederick Preston, production manager, and Mr. F. Hobson, chief engineer, have been appointed local directors. Mr. E. G. Odds has retired from the board, and his place is being taken by Mr. J. L. Ritchie. Mr. S. H. Billson has been appointed secretary of the company.

THE ELECTRICAL RESEARCH ASSOCIATION announces the following appointments :—Mr. L. Gosland, research manager ; Mr. E. E. Hutchings, head of the member relations department ; Mr. A. M. Cassie and Dr. L. H. Orton, joint heads of the switchgear department ; Dr. G. Mole and Dr. F. Busemann, head and deputy head respectively of the transmission and utilisation department.

THE PENINSULAR AND ORIENTAL STEAM NAVIGATION COMPANY, Ltd., has announced that Mr. S. A. Smith, who has been associated with the company for forty-six years, is to retire at the end of this year and will be succeeded as engineer adviser to the company by Mr. T. W. Bunyan, who has recently resigned from the post of principal engineer surveyor for research of Lloyd's Register of Shipping.

## Business Announcements

POLYPENCO, Ltd., has opened an office and factory at Tewin Road, Welwyn Garden City, Herts.

STUART B. DICKENS, Ltd., has opened a branch office at Elizabeth House, Pritchard Street, Johannesburg.

MR. PETER COLECLOUGH, export director of Rotary Hoes, Ltd., has left for a tour of the U.S.A., Canada, Mexico and Cuba.

BX PLASTICS, Ltd., states that " Bexlene " has been registered as the trade name for " Terylene Velbex " laminated material.

BRIGHTON INDUSTRIES, Ltd., has moved its headquarters to a new factory at Burgess Hill, Sussex (telephone, Burgess Hill 85611).

G.W.B. FURNACES, Ltd., Dudley, states that it has opened a London office at Sicilian House, 7, Sicilian Avenue, W.C.1 (telephone, Chancery 6727).

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that the telephone number of its depot at Camden Street, Derby, has been changed to Derby 41421.

THE BRITISH REINFORCED CONCRETE ENGINEERING COMPANY, Ltd., states that Mr. Harold Walker, director in charge of overseas business, is visiting North America.

THE UNITED COKE AND CHEMICALS COMPANY, Ltd., states that its sales office is now located at the company's Orgreave Works, P.O. Box No. 136, Handsworth, Sheffield, 13 (telephone, Sheffield 63025 and Woodhouse 40241).

MR. SYDNEY S. GUY, M.I.Mech.E., who founded Guy Motors, Ltd., Wolverhampton, forty-three years ago, is retiring from the offices of chairman and managing director of the company and its associate, The Sunbeam Trolleybus Company, Ltd.

TUBE INVESTMENTS, Ltd., states that, subject to Treasury approval and the completion of formalities, it has made an agreement with the Reynolds Metals Group, of the U.S.A., to combine the interests of both groups in the United Kingdom's aluminium industry.

BRITISH MONORAIL, Ltd., announces that the entire British shareholding has been acquired by a group of industrialists headed by Mr. James Dallas. The company will continue to operate from Wren Works, Chadderton, Lancs. Mr. Dallas has been appointed chairman and managing director and Mr. John Lund is the technical director.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., states that Mr. A. S. Kettle, M.I.E.E., consultant to the construction department and service engineers department, has retired. It has also announced the retirement of Mr. J. M. Goodall, M.I.E.E., consulting switchgear engineer at the Willesden Works, after forty-nine years with the company.

THE DOLLAR EXPORTS COUNCIL is organising a delegation to Western Canada during October. Mr. Halford Reddish, chairman and managing director of the Rugby Portland Cement Company, Ltd., is to lead the delegation ; he will be accompanied by Mr. J. W. Whiter, managing director of Richard Costain, Ltd., and Mr. F. Davies, of the North American Department of the Federation of British Industries.

LAURENCE, SCOTT AND ELECTROMOTORS, Ltd., states that the major parts of the Bedfordshire and Hertfordshire areas have been transferred to the London sales area. Mr. C. A. Bendall, who has charge of industrial sales in East Anglia, now operates from the London office at Manfield House, Southampton Street, Strand, W.C.2. Mr. P. Groom is the company's industrial equipment representative for East Anglia, operating from the Norwich works.

## Contracts

RANSOMES SIMS AND JEFFERIES, Ltd., Ipswich, has received an order from Maison Henri Perrier, Paris, for 280 MG.6 crawler tractors.

INTERNATIONAL HARVESTER COMPANY OF GREAT BRITAIN, Ltd., has received an order from Canada for a further 900 B-250 agricultural tractors.

THOMAS ROBINSON AND SON, Ltd., Rochdale, has received a contract from Republic Flourmills, Incorporated, for the design and equipment of the first flour mill to be built in the Philippines. The mill will be able to handle about 240 tons of wheat a day.

## Miscellanea

EPOXIDE TOOLS.—There is now available from Aero Research, Ltd., Duxford, Cambridge, a booklet entitled " Araldite Resins for Tooling." " Araldite " resins, obtained by the condensation of epichlorhydrin and diphenylol propane, can be cured to stable forms of great hardness or rubbery resilience, and are an economic material for reference, short life, or urgently required tools. Descriptions are given of the processes of making jigs and fixtures, press tools and dies, stretch blocks and vacuum forming tools, matched and rubber bag moulds for laminated plastics, and joggle and hammer blocks. The various mixes required for facing or strengthening the tools are prescribed, and the sources of fillers, release agents and barrier creams listed.

HIGH-HEAD PUMP.—An automatic self-priming portable centrifugal pump now being made by Goodenough Pumps, Ltd., Byfleet, Surrey, is designed for quick re-priming at suction lifts of up to 25ft. Priming is achieved by re-circulation and the pump will deliver 8000 gallons per hour against a total head of 150ft, or 12,000 gallons against a total head of 100ft. The pump, which is fitted with 3in inlet and outlet connections, is made in non-corrosive aluminium alloy whilst the impeller is in manganese bronze. It is direct coupled to either a twin-cylinder air-cooled diesel engine or a twin-cylinder air-cooled petrol engine and is mounted on a two wheel rubber tyred trolley.

METAL PRIMING.—A combined etch priming and metal conditioning compound has been introduced by Supra Chemicals and Paints, Ltd., Hainge Road, Tividale, Tipton, Staffs. When applied to metal this etch primer is stated to provide an excellent adhesive bond for subsequent paint films without elaborate chemical preparatory work other than simple solvent degreasing. It also provides a very thin anti-corrosive film with a high corrosion resistance on the surface of the metal. It is supplied as a pigmented base paint and an accelerator thinner which have to be thoroughly mixed in equal proportions. The resultant paint is suitable for brush application or for spraying at a pressure of approximately 40 lb per square inch.

LIGHT POWER TRUCK.—A lightweight truck now being made by Whades (Sussex), Ltd., Duke Street, Littlehampton, is available with a platform body or a tipping box body with a hinged tail board. The power unit is a 147 c.c. Villiers two-stroke petrol engine mounted in a tubular frame on the single front wheel which is driven through a chain and epicyclic gearing. A single throttle control is used and an automatic clutch is engaged as the engine is accelerated above a preset idling speed. The complete engine and front wheel assembly is turned in the frame for steering purposes and it can be rotated through a full circle. The platform body is 5ft 3in long by 2ft 6in wide and is designed to carry up to 10 cwt. This body is secured to the power assembly frame through keyhole slots and can be quickly removed and replaced by the ½ cubic yard capacity tipping body. The platform body is available with a ratchet operated hand winch and a rear roller ramp to enable heavy articles to be drawn on the floor without need for lifting.

PROPOSAL FOR RESERVOIR ON THE RIVER DERWENT.—Mr. Henry Brooke, Minister of Housing and Local Government, has agreed in principle to a proposal to dam the River Derwent, near Edmondbyers, where it forms the boundary between Northumberland and Durham, in order to create a reservoir which will flood 947 acres of land and have a capacity of 11,000 million gallons. It will yield 26,000,000 gallons of water a day. The application to the Minister for an order authorising the work was made jointly by the Durham County Water Board and the Sunderland and South Shields Water Company. The public inquiry into the application, held on April 24,, also covered some of the planning problems raised by the scheme, and in agreeing to the scheme the Minister has made conditions requiring that where development will affect the landscape, there shall be agreed schemes of landscaping which may include tree and shrub planting, the formation of banks or slopes and grass seeding, so as to make the development blend with the landscape.

CONDENSER PROTECTION.—Filming amines employed in small quantities of the order of 1–5 p.p.m. in steam will provide a high degree of protection to metals in contact with low pH condensate by plating out as a thin impermeable film on the wetted surfaces. The material is easy to handle and is simply administered by injection to the boiler feed line, the boiler itself or to the steam line. No impedance is offered to heat transfer by the deposition of the corrosion resisting barrier on the condensing surfaces, and in fact the rate of heat transfer may be increased by 5–10 per cent, due to the removal of existing corrosion products by the amine and the promotion of dropwise condensation of the steam. In cooling systems the quaternary ammonium salts and acetate salts of certain fatty acid derived amines prevent algæ growth and inhibit corrosion. Heat transfer is improved by removal of corrosion products and the general cleaning effect of the amine. Filming amines, manufactured in the United Kingdom, are supplied by Armour and Co., Ltd., Chemical Division, London. These amines are distributed for water treatment in the United Kingdom and abroad by Houseman and Thompson, Ltd., who are able to offer a complete advisory service on their application to industrial steam and water systems.

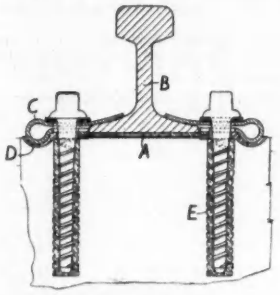
# British Patent Specifications

*When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.*

## RAILWAY ENGINEERING

**782,180.** September 22, 1954.—MEANS FOR SUPPORTING RAIL TRACKS, The Clyde Rubber Works Company, Ltd., and Douglas Millar Hannah, both of the company's address, Porterfield Road, Renfrew, Renfrewshire, Scotland.

Objects of the invention are to provide for ease of mounting a flat bottomed rail or a rail and associated chairs on sleepers and for ease of maintenance of the permanent way. Referring to the drawing, *A* is a pad of resilient material interposed between the lower flange of a flat bottomed rail *B* or a chair and an associated sleeper. A holding-down bolt is threaded into a sleeve *E* of elastically deformable material, preferably compounded natural or synthetic rubber, in a socket in the sleeper. A clamping member *C* is carried on a resilient pad *D* and a washer of resilient material is interposed between the head of the

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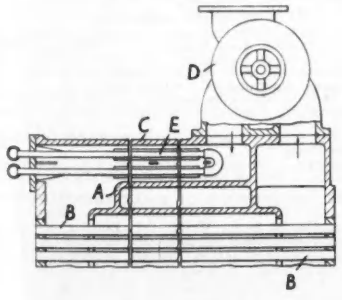
bolt and the member *C*. The pads *A* and *G* and the washer are preferably of compounded natural or synthetic rubber, so that the rail is insulated from the sleeper. The sleeve *E* is provided for part of its length with external screw threads, or it may, alternatively, be of polygonal form, in which case it is serrated externally. The sleeve is formed with a longitudinal groove with which is engageable a key formed within the associated sleeper to prevent rotation of the sleeve. Modified designs are also shown in the specification. When the coach screw is then threaded into and tightened into the sleeve, it expands into firm engagement in the sleeper. —*September* 4, 1957.

## INTERNAL COMBUSTION ENGINES

**781,332.** April 12, 1955.—TUBULAR HEAT EXCHANGE APPARATUS, Serck Radiators, Ltd., Warwick Road, Greet, Birmingham, 11. (*Inventor: Henry Edward Upton.*)

The invention relates to a cooler for engine oil or other viscous liquid, which flows over the tubes, the cooling medium flowing through the tubes. Its object is to enable a heating means to be combined with the cooler in a convenient manner, for warming and thereby reducing the viscosity of cold and

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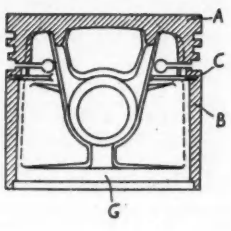
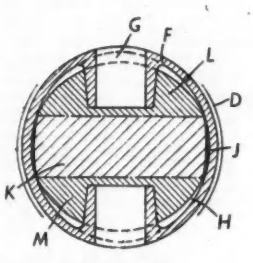
stagnant liquid in the housing prior to bringing the apparatus into normal use. In the drawing the main part of the cooler is of known form and comprises a cylindrical housing *A* in which is contained an assembly of tubes *B* arranged parallel with each other. While flowing over the tubes the oil is caused to travel in a zig-zag path formed by baffle plates mounted on the tubes. The cooling medium, which may be water, is conveyed through the tubes by way of headers mounted on the ends of the housing. In applying the invention as shown in the drawings, there is formed on or attached to the exterior of the housing a longitudinal duct *C* by which the oil is conveyed to one end of the housing, and at the inlet end of the duct is mounted a valve *D* which controls the inflow of oil and may also control the outflow from an exit arranged adjacent to the inlet. In the duct is a longitudinally arranged tube of U-form or an assembly of tubes *E* for conveying steam or hot water. When it is required to bring the apparatus into use after standing idle for a time, the heater is first used to warm the oil in the duct and housing, and reduce its viscosity sufficiently to enable the incoming hot oil to flow without undue resistance through the housing.—*August* 21, 1957.

**782,248.** January 18, 1956.—LIGHT METAL PISTON, Karl Schmidt G.m.b.H., 10, Fabrikstrasse, Neckarsulm, Württemberg, Germany.

The invention relates to pistons of light metal alloys for internal combustion engines, of a construction in which the piston skirt consists of a single metallic material and in which expansion regulating members of materials having a lower coefficient of thermal expansion, such as iron alloys, are provided. As shown in the drawing, the piston of light metal is cross-slotted so that the head *A* is separated from the skirt *B*. In the upper part of the skirt there is an expansion-restricting or regulating member *C* of iron alloy. However, the invention also embraces smooth-walled, solid-skirt, single-metal pistons not having the feature of slotting between the head and the skirt walls. The skirt walls are of varying thickness. Along the bearing surfaces *D*, the thickness is greatest.

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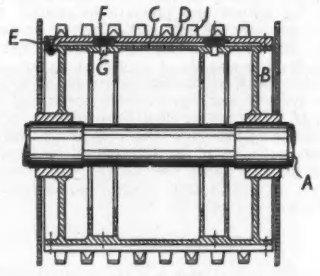
Beneath the gudgeon pin sockets *F*, stiffening ribs are also provided, which in the axial centre of the sockets at *G* have the highest moment of resistance, and therefore the greatest cross-section. These stiffening ribs are sickle-shaped and at their pointed ends *H* run into the walls. At the points where the wall of the skirt is thickest, the bearing surface wall is also provided with an integral reinforcement *J* running like a chord. In order to cast the piston, in addition to the mould, a three-part core, with the middle part *K* and the two sides, parts *L* and *M*, is used. The entire triple core bundle is made oval, the greatest diameter of the oval lying in the direction of the axis of the gudgeon pin, and the smallest at right-angles thereto. By correspondingly stepping the contour of the middle core *K*, it is possible to produce the thickening *J* during casting. In this way it is possible to produce a stiff open skirt of the piston, which is sufficiently protected against falling-in of the bearing surfaces. The piston can be produced in automatic or semi-automatic casting machines.—*September* 4, 1957.

## CRUSHING MILLS

**780,489.** April 13, 1954.—ROLLS FOR CRUSHING MILLS, Westfalia Dinnendahl Groppel Aktiengesellschaft, Bochum, Germany.

The invention consists in a roll in which crushing plate segments are laid on a hollow supporting drum and secured to it by bolts at the ends of the plates. The changing of the crushing plate segments is a simple operation and can be carried out without it being necessary to dismantle the roll itself. According to the drawing, there is mounted on the shaft *A* the supporting drum *B*. On the drum shell *C* are placed the crushing plate segments *D*. Each crushing plate is held at both ends by two bolts *E* passing through clearance openings in the plate and which only serve to tighten the plate against the shell. The plate has on its underside recesses *F* for receiving the thrust bolts *G*. Each recess is so formed that the head of the thrust bolt is inserted in the operative direction of the roll with

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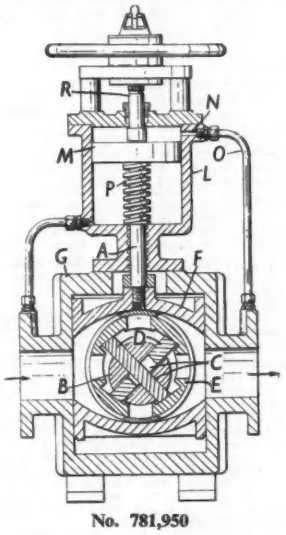
a driving fit, whereas perpendicular to that direction it has a certain amount of clearance. The thrust bolt *G* is in the drum shell and a drive fit takes up the pressure exerted in the operative direction. At the places where the thrust bolts are inserted, the supporting drum is reinforced by stiffening rings of U- or I-shaped cross-section. The outer side of crushing plate *D* is set with the crushing teeth *J*, and round-headed conical bosses are provided between them.—*August* 7, 1957.

## PUMPS

**781,950.** November 17, 1954.—VARIABLE-CAPACITY PUMPS, Plenty and Son, Ltd., Eagle Iron Works, Newbury, Berkshire. (*Inventor: Guy Taite Shoosmith.*)

The invention relates to the control of variable-capacity fluid pumps, and is concerned more specifically with the problem of preventing a prime mover which drives such a pump from being overloaded when the delivery pressure of the fluid begins to build up beyond its normal upper value for a particular setting of the capacity-adjusting member of the pump. The example shown in the drawing is a manually-controlled, variable-capacity pump, the capacity-adjusting member *A* being hand operated except when the overload-prevention mechanism of the invention takes control. The pump is of the sliding vane type, comprising a rotor shaft *B* having a number of radial slots *C* in which are mounted to slide vanes *D* which bear at their outer ends on an annular stator *E*

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carried by a cage *F*. The cage forms a pumping chamber and is mounted for vertical movement within the pump casing *G* and the eccentricity of the stator relatively to the rotor shaft can be varied to adjust the capacity of the pump. In such pumps, the cage *F* is generally connected to a spindle which is moved up and down to vary the position of the stator relatively to the rotor by rotation of a hand-wheel at the upper end of the spindle. In the pump under consideration, however, the capacity-adjusting spindle *A* passes into a closed cylinder *L* above the pumping chamber and is connected to a substantially fluid-tight piston *M* sliding within the cylinder. The cylinder has a port *N* at its upper end connected by a pipe *O* to the delivery side of the pump so that the delivery pressure of the fluid is transmitted to the upper face of the piston *M*. On the spindle, beneath the piston, is a spring *P* which urges the piston

towards the top of the cylinder against the pressure of the fluid. The cylinder and spring-loaded piston therefore constitute a pressure-sensitive device which, when the delivery pressure of the fluid exceeds a value determined by the strength of the spring, causes the capacity-adjusting spindle *A* to be moved to reduce the capacity of the pump and, therefore, to adjust the output and pressure in relation to the normal capacity of the prime mover driving the pump. For all normal adjustment of the capacity of the pump, the spindle *A* is moved by an axially-adjustable rod *R* which passes through the upper end of the cylinder and bears on the upper face of the piston *M*. This rod serves to limit the upward movement of the piston under the influence of the spring and can be adjusted by rotation of a handwheel carried on the upper end of the rod. A servo-operated variable capacity pump is also shown in the specification.—*August* 28, 1957.

# Forthcoming Engagements

*Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the* TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

### ASSOCIATION OF BUILDING TECHNICIANS

*To-day, Oct.* 4.—LONDON BRANCH: Building Centre, Store Street, London, W.C.1, "Building for Atomic Power," E. L. Ashley, to be followed by a film "The Construction of Calder Hall," 6.30 p.m.

### ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

*To-day, Oct.* 4.—BRISTOL AND WEST OF ENGLAND BRANCH: Royal York Hotel, Bath, Film Show, 8 p.m. ★ LIVERPOOL AND DISTRICT BRANCH: Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "Earthing and its Problems," P. W. Cave, 7.30 p.m.

*Sat., Oct.* 5.—OXFORD, READING AND DISTRICTS BRANCH: Hampden Buildings, Temple Square, Aylesbury, "The Thirteenth Edition of the I.E.E. Wire Regulations," J. J. Looker, 7 p.m.

*Mon., Oct.* 7.—LEEDS BRANCH: Great Northern Hotel, Leeds, "Radiations for Diagnostic and Therapeutic Purposes," A. E. Holland, 7.30 p.m. ★ N.E. LONDON BRANCH: Angel Hotel, Ilford, "Push Button Housekeeping," Mrs. M. E. Pickford, 8 p.m. ★ SHEFFIELD BRANCH: Royal Victoria Station Hotel, Sheffield, "Automatic Heating Controls," G. C. Fox, 7.30 p.m.

*Tues., Oct.* 8.—PORTSMOUTH AND DISTRICT BRANCH: Wiltshire Lamb Hotel, Portsmouth, "Safety in Electrical Installations," S. J. Emerson, 7.30 p.m. ★ YORK BRANCH: Royal Station Hotel, York, "Switchgear and Motor Control Gear," J. F. Cummings, 7.30 p.m.

*Wed., Oct.* 9.—BIRMINGHAM BRANCH: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "Plastics in the Electrical Industry," S. F. Sandford and W. E. Downing, 7.30 p.m. ★ HALIFAX BRANCH: Crown Hotel, Horton Street, Halifax, "Some Aspects of Street Lighting," J. H. Mollan, 7.45 p.m.

*Thurs., Oct.* 10.—S.W. LONDON BRANCH: Prince of Wales Hotel, Wimbledon, London, S.W.19, open debate on "Wiring Systems," 8.30 p.m.

*Fri., Oct.* 11.—STOKE AND CREWE BRANCH: Grand Hotel, Hanley, Stoke, "Earth Leakage Protection of Domestic and Similar Installations," J. A. Robbins, 7.30 p.m.

### BRITISH INSTITUTION OF RADIO ENGINEERS

*To-day, Oct.* 4.—S. MIDLANDS SECTION: North Gloucestershire Technical College, Cheltenham, "Radio Engineering in the Post Office," C. T. Lamping, 7 p.m.

*Wed., Oct.* 9.—N.E. SECTION: Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, "High Fidelity Loud Speakers," R. A. Bull, 6 p.m. ★ W. MIDLANDS SECTION: Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton, "Transistors—Circuits and Applications," M. D. Cooper, 7.15 p.m.

*Thurs., Oct.* 10.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Reception Problems of Scottish Television," W. Boyd, 7 p.m.

### ILLUMINATING ENGINEERING SOCIETY

*Tues., Oct.* 8.—LONDON MEETING: Royal Institution, Albemarle Street, London, W.1, Presidential Address, "Designing for Harmony," E. B. Sawyer, 6 p.m.

*Thurs., Oct.* 10.—NOTTINGHAM CENTRE: Demonstration Theatre, East Midlands Electricity Board, Smithy Row, Nottingham, Chairman's Induction and visit of the President, 6 p.m.

### INCORPORATED PLANT ENGINEERS

*Tues., Oct.* 8.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "Chain Grate Stokers," C. H. G. Hayward, 7.15 p.m.

*Thurs., Oct.* 10.—GLASGOW BRANCH: Scottish Building Centre, 425–427, Sauchiehall Street, Glasgow, "The Measurement and Prevention of Smoke from Industrial Boilers," T. F. Hurley, 7.15 p.m. ★ MANCHESTER BRANCH AND MERSEYSIDE AND N. WALES BRANCH: Joint Meeting, Aboard Clubship "Landfall," "What Purpose does Incorporated Plant Engineers Serve?" 7.15 p.m. ★ N.E. BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "The Manufacture of Tubes," H. B. Elliot, 7 p.m.

### INSTITUTE OF BRITISH FOUNDRYMEN

*Tues., Oct.* 8.—SLOUGH SECTION: Lecture Theatre, High Duty Alloys, Ltd., Slough, "The Know-How of the $CO_2$ Process," A Brains Trust, 7.30 p.m.

*Thurs., Oct.* 10.—BEDS AND HERTS SECTION: K. and L. Steelfounders and Engineers, Ltd., Letchworth, Presidential Evening, G. Smith, 7.30 p.m.

### INSTITUTE OF FUEL

*Wed., Oct.* 9.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Symposium on "Flames and Industry," 10 a.m.

### INSTITUTE OF MARINE ENGINEERS

*Mon., Oct.* 7.—MERSEYSIDE AND N.W. SECTION: Liverpool Engineering Society, The Temple, Dale Street, Liverpool, "Marine Machinery Breakdown," J. H. Milton, 6 p.m.

*Tues., Oct.* 8.—Memorial Building, 76, Mark Lane, London, E.C.3, "Recent Developments in British Naval Main Propulsion Steam Turbines," F. J. Cowlin and A. F. Veitch, 5.30 p.m.

*Wed., Oct.* 9.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Developments and Trends in the Marine Field," W. Young, 7.30 p.m.

*Thurs., Oct.* 10.—W. MIDLANDS SECTION: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "Turbocharging of Two-Stroke Oil Engines," W. G. Cowland, 7 p.m. ★ KINGSTON UPON HULL AND E. MIDLANDS SECTION: Royal Station Hotel, Kingston upon Hull, "Modern Methods of Shipbuilding," R. S. Hogg, 7.30 p.m.

*Mon., Oct.* 14.—STUDENT MEETING: Memorial Building, 76, Mark Lane, London, E.C.3, Films, "Super Tanker" and "Foothold on Antarctica," 6.30 p.m.

### INSTITUTE OF METALS

*Tues., Oct.* 8.—S. WALES LOCAL SECTION: Department of Metallurgy, University College, Singleton Park, Swansea, "Pure Metals," J. C. Chaston, 6.30 p.m.

*Thurs., Oct.* 10.—BIRMINGHAM LOCAL SECTION: College of Technology, Gosta Green, Birmingham, "The Production of Wrought Forms in Titanium and Titanium Alloys," J. R. Crane, 6.30 p.m.

### INSTITUTE OF ROAD TRANSPORT ENGINEERS

*Mon., Oct.* 7.—E. REGIONAL CENTRE (N.W.C.): Council Chamber, Houldsworth Hall, 90, Deansgate, Manchester, "Trends of Modern Passenger Transport," R. Cox, 7.30 p.m. ★ SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Exhaust Brake Design and Operation," A. G. Slee and W. K. Cox, 7.30 p.m.

*Tues., Oct.* 8.—MIDLANDS CENTRE: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "The Use of Plastics in Road Transport," M. D. Curwen, 7.30 p.m. ★ W. CENTRE: Royal Hotel, Bristol, "The Free Piston Gasifier with special reference to Vehicle Application," 6.30 p.m. ★ E. CENTRE: County Hotel, Chelmsford, "The Development and Operation of Disc Brakes," T. J. Phipps, 7 p.m.

*Wed., Oct.* 9.—S. CENTRE: Preston Technical Institute, Brighton, "Wear and Tear," J. E. Johnson, 7.30 p.m.

*Fri., Oct.* 11.—W. CENTRE: Rougemont Hotel, Exeter, "High Pressure and Syndromic Lubrication Systems," W. T. Kay, 7 p.m. ★ S. WALES CENTRE: Visit to the works of Guest, Keen Iron and Steel Company, East Moors, Cardiff, 2.15 p.m. ★ S. WALES CENTRE: South Wales Institute of Engineers, Park Place, Cardiff, "The Operation and Development of Disc Brakes," T. J. Phipps, 7 p.m.

### INSTITUTION OF CHEMICAL ENGINEERS

*Mon., Oct.* 7.—LONDON BRANCH: Federation of British Industries, 21, Tothill Street, London, S.W.1, "The Effect of Temperature on Bursting Discs," H. R. Wright: "The Effect of Temperature on Bursting Discs," T. B. Philip, and "The Effect of Operating Temperature on Bursting Discs," J. W. F. Brown, 5.30 p.m.

### INSTITUTION OF CIVIL ENGINEERS

*Tues., Oct.* 8.—Great George Street, Westminster, London, S.W.1, "Investigation of Rainfall, Run-off and Yield on the Alwen-Brenig Catchments," W. K. Lewis, 5.30 p.m.

### INSTITUTION OF ELECTRICAL ENGINEERS

*To-day, Oct.* 4.—N. SCOTLAND SUB-CENTRE: Robert Gordon's Technical College, Aberdeen, Chairman's Address, E. O. Taylor, 7.30 p.m.

*Mon., Oct.* 7.—E. ANGLIAN SUB-CENTRE: Assembly House, Norwich, Chairman's Address, "Education for Engineers," G. E. Middleton, 7.30 p.m. ★ MERSEY AND N. WALES CENTRE: Royal Institute, Colquitt Street, Liverpool, Chairman's Address, "Development of Electrical Services in a Soap and Chemical Factory," T. Makin, 6.30 p.m. ★ S. MIDLAND CENTRE: Grand Hotel, Birmingham, Chairman's Address, L. I. Tolley, and Annual General Meeting, and Conversazione, 6 p.m.

*Tues., Oct.* 8.—MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, Chairman's Address, "Meters and Meter Engineers," H. S. Petch, 5.30 p.m. ★ E. MIDLAND CENTRE: Loughborough College, Chairman's Address, J. D. Pierce, and Annual General Meeting, 6.30 p.m. ★ CAMBRIDGE RADIO AND TELECOMMUNICATION GROUP: Cambridgeshire Technical College, Chairman's Address, N. C. Rolfe, 6.30 p.m. ★ N.W. UTILIZATION GROUP: Engineers' Club, 17, Albert Square, Manchester, "Electrical Floor Warming," J. W. Moule and W. M. Stevenson, 6.15 p.m. ★ N. IRELAND CENTRE: David Keir Building, Queen's University, Belfast, Chairman's Address, "Brief Review of the Progress of the Electricity Board for Northern Ireland," C. M. Stoupe, 6.30 p.m.

*Wed., Oct.* 9.—LONDON GRADUATE AND STUDENT SECTION: Savoy Place, London, W.C.2, Chairman's Address, "Tacan—A New Air Navigational System," F. L. Fielding, 6.30 p.m. ★ N.W. RADIO AND TELECOMMUNICATION GROUP: Engineers' Club, 17, Albert Square, Manchester, Chairman's Address, K. J. Butler, 6.45 p.m. ★ N. LANCASHIRE SUB-CENTRE: N.W. Electricity Board Demonstration Theatre, 19, Friargate, Preston, Chairman's Address, H. G. Cope, 7.15 p.m. ★ RUGBY SUB-CENTRE: Rugby College of Technology and Arts, Chairman's Address, W. J. Carfrae, 6.30 p.m. ★ OXFORD BRANCH: S. Electricity Board, 37, George Street, Oxford, "Visit of Electrical Delegation to Russia," D. P. Sayers, 7 p.m.

*Thurs., Oct.* 10.—UTILIZATION SECTION: Savoy Place, London, W.C.2, Chairman's Address, "Joints and Hinges," J. Vaughan Harries, 5.30 p.m. ★ N. MIDLAND CENTRE: Yorkshire Electricity Board, Ferensway, Hull, "A New Meter for the kVA Demand Charge," P. Baxter, 6.30 p.m. ★ W. WALES (SWANSEA) SUB-CENTRE: S. Wales Electricity Board Showrooms, The Kingsway, Swansea, Chairman's Address, I. G. Evans, 6 p.m.

*Mon., Oct.* 14.—INFORMAL MEETING: Savoy Place, London, W.C.2, Discussion on "The Social Consequences of Automation," to be opened by the President, 5.30 p.m. ★ N.E. CENTRE: Neville Hall, Newcastle upon Tyne, Chairman's Address, T. W. Wilcox, 6.15 p.m. ★ N. STAFFORDSHIRE SUB-CENTRE: Jubilee Hall, Stoke-on-Trent, Chairman's Address, H. A. P. Caddell, 7 p.m. ★ WESTERN CENTRE: South Wales Institute of Engineers, Cardiff, Chairman's Address, J. F. Wright, 6 p.m.

*Tues., Oct.* 15.—N. MIDLAND CENTRE: Central Electricity Authority, Yorkshire Division, 1, Whitehall Road, Leeds, "Electrical Equipment for Rectifier Locomotives," H. B. Calverley, E. A. K. Jarvis and E. Williams, 6.30 p.m. ★ N.W. SUPPLY GROUP: Engineers' Club, Albert Square, Manchester, "Experiences in the U.S.S.R.," H. West, 6.15 p.m. ★ S.E. SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, Sub-Centre Chairman's Address, J. Mendelson, 7 p.m. ★ S.W. SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Sub-Centre Chairman's Address, A. J. Small, 7 p.m.

### INSTITUTION OF ENGINEERING DESIGNERS

*Mon., Oct.* 14.—N.E. BRANCH: Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "Building Structures," G. Gladstone, 7.15 p.m.

### INSTITUTION OF ENGINEERS IN CHARGE

*Wed., Oct.* 9.—Caxton Hall, Caxton Street, Westminster, London, S.W.1, Forty-Fourth Annual General Meeting, 6.30 p.m.

*Fri., Oct.* 25.—Caxton Hall, Caxton Street, Westminster, London, S.W.1, Presidential Address, Sir Harold Roxbee Cox, 6.30 p.m.

### INSTITUTION OF HIGHWAY ENGINEERS

*To-day, Oct.* 4.—LONDON BRANCH: Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "Construction of Soil Cement Roads and Road Bases in Holland," F. A. Van der Sluis, 5.30 p.m.

### INSTITUTION OF MECHANICAL ENGINEERS

*To-day, Oct.* 4.—BARROW-IN-FURNESS PANEL: Central College for Further Education, Lecture Theatre, Abbey Road, Barrow-in-Furness, "The Steam Catapult," C. C. Mitchell and Q. H. Paterson, 7.30 p.m.

*Mon., Oct.* 7.—N.E. BRANCH: Neville Hall, Westgate Road, Newcastle upon Tyne, Chairman's Address, 6 p.m.

*Tues., Oct.* 8.—AUTOMOBILE DIVISION: 1, Birdcage Walk, Westminster, London, S.W.1, Annual General Meeting, followed by the Chairman's Address, 6 p.m. ★ EASTERN BRANCH: Red Lion Hotel, Colchester, Chairman's Address, "Heat and Power for Industry: Some Technical Considerations of the Effect of Current Trends in the Availability of Fuel," G. W. Bone, 7.30 p.m. ★ RUGBY PANEL: Lawrence Sheriff School, Rugby, "Motive Power on Sea and Land," T. A. Crowe, 6.30 p.m. ★ N.E. BRANCH: Cleveland Institute, Corporation Road, Middlesbrough, Chairman's Address, 6.15 p.m. ★ S. WALES BRANCH: S. Wales Electricity Board's Lecture Theatre, Kingsway, Swansea, "Applications of Radioisotopes to Engineering," D. B. Smith, 6 p.m.

*Wed., Oct.* 9.—INTERNAL COMBUSTION ENGINE GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Are the Diesel Engine and the Petrol Engine Merging?" 6.45 p.m. ★ E. MIDLANDS BRANCH: Royal Hotel, Grimsby, Joint Meeting with the E. Midlands Local Association of the Institution of Civil Engineers, "The Design and Construction of Aden Oil Harbour," J. E. G. Palmer and H. Scrutton, 7.30 p.m. ★ LUTON A.D. CENTRE: Luton Town Hall, Luton, Address by the Chairman of the Automobile Division, 7.30 p.m.

*Thurs., Oct.* 10.—N.W. INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP: Reynolds Hall, College of Science and Technology, Manchester, "The Economics of Plant Replacement," C. W. Griffiths, 6.45 p.m. ★ SCOTTISH BRANCH: Royal College of Science and Technology, Glasgow, "Impressions of Technical Education in America and Russia," A. S. T. Thomson, 7.30 p.m. ★ YORKSHIRE BRANCH: University Chemistry Lecture Theatre, Leeds, "The Governing of Compression-Ignition Oil Engines," D. B. Welbourn, D. K. Roberts and R. A. Fuller, 6.30 p.m. ★ E. MIDLANDS GRADUATE SECTION: Research Centre of Ruston and Hornsby, Ltd., Lincoln, "The Testing and Development of Internal Combustion Engines," J. H. Weaving, 7.15 p.m.

### INSTITUTION OF MINING AND METALLURGY

*Thurs., Oct.* 17.—GENERAL MEETING: Geological Society, Burlington House, Piccadilly, London, W.1, "Control of Air Pressure as an Aid to Fight Mine Fires," J. M. Caw, and "The Production of Zinc in a Blast Furnace," S. W. K. Morgan, 5 p.m.

### INSTITUTION OF NAVAL ARCHITECTS

*Thurs., Oct.* 10.—Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, "Some Problems of Yacht Measurement," D. Phillips-Birt, 4.45 p.m.

### INSTITUTION OF PRODUCTION ENGINEERS

*To-day, Oct.* 4.—Dorchester Hotel, Park Lane, London, W.1, Annual Dinner. ★ EASTERN REGION: Britannia Works Canteen, Davey, Paxman and Co., Ltd., Colchester, "Automation—Development of Transfer Equipment," A. J. Sephton, 7.30 p.m.

*Tues., Oct.* 8.—BIRMINGHAM GRADUATE SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Developments and Applications of the Manufacture of Fibre Glass," A. Pimblett, 7 p.m.

*Wed., Oct.* 9.—LIVERPOOL BRANCH: Exchange Hotel, Tithebarn Street, Liverpool, "Design for Production," W. Moore, 7.30 p.m.

*Thurs., Oct.* 10.—LEICESTER BRANCH: Taylor, Taylor and Hobson Ltd., Stoughton Street, Leicester, "Lens Manufacture," G. M. Green, 7 p.m. ★ SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "Russian Survey," Norman Stubbs and Peter Trippe, 7.15 p.m.

### INSTITUTION OF WORKS MANAGERS

*Mon., Oct.* 7.—TYNE-WEAR BRANCH: Conference Room, Ministry of Labour and National Service, 93a, Grey Street, Newcastle upon Tyne, "Industrial Engineering," C. Fitton, 6.30 p.m.

*Tues., Oct.* 8.—BIRMINGHAM BRANCH: Byng Kenrick Suite, New College, Birmingham College of Technology, Gosta Green, Birmingham, "Industrial Relations To-day," Sir Frederick Leggatt, 7 p.m.

*Thurs., Oct.* 10.—DONCASTER BRANCH: Danum Hotel, Doncaster, "Britain's Economic Future," H. S. Wincott, 7.30 p.m.

### JUNIOR INSTITUTION OF ENGINEERS

*To-day, Oct.* 4.—LONDON SECTION: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Opening Meeting of 1957–58 Session, 7 p.m.

*Tues., Oct.* 8.—N.W. SECTION: Engineers' Club, Albert Square, Manchester, President's Address, T. S. Dickinson, 7.30 p.m.

*Fri., Oct.* 11.—ORDINARY MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "The Microscope in Engineering," Arthur E. Bingham, 7 p.m.

### LIVERPOOL METALLURGICAL SOCIETY

*Thurs., Oct.* 10.—Liverpool Engineering Society, The Temple, Dale Street, Liverpool, Presidential Address, J. S. W. Graham, 7 p.m.

### MANCHESTER GEOLOGICAL AND MINING SOCIETY

*Thurs., Oct.* 10.—Mining and Technical College, Wigan, Annual General Meeting, 3.30 p.m.

### NEWCOMEN SOCIETY

*Wed., Oct.* 9.—Lecture Theatre, Science Museum, South Kensington, London, S.W.7, A Special General Meeting, followed by "Early Steam Engines in Derbyshire," Frank Nixon, 5.30 p.m.

### PIPELINE INDUSTRIES GUILD

*Tues., Oct.* 8.—THIRD GENERAL MEETING: Lancaster Room, Caxton Hall, Caxton Street, Westminster, London, S.W.1, "Pipes as Water Mains," H. R. Lupton, 6.30 p.m.

### PLASTICS INSTITUTE

*To-day, Oct.* 4.—FIFTH EDUCATION CONFERENCE: Borough Polytechnic, Borough Road, London, S.E.1, "Challenge of Plastics to the Arts and Technology," Sir Miles Thomas, 2.30 p.m. ★ Science Museum, South Kensington, London, S.W.7, President's Reception and Conversazione, 8 p.m.

*Mon., Oct.* 7.—MIDLANDS SECTION: Grand Hotel, Leicester, "Engineering Applications of Epoxide Resins," S. Slaney, 6.45 p.m.

*Wed., Oct.* 9.—N.W. SECTION: Visit to The British Northrup Loom Company, Ltd., Blackburn, 2 p.m.

*Fri., Oct.* 11.—N.W. SECTION: Engineers' Club, Albert Square, Manchester, Technical Film Evening, 6.45 p.m.

### ROYAL INSTITUTION OF CHARTERED SURVEYORS

*Thurs., Oct.* 10.—LAND SURVEYORS GENERAL MEETING: 12, Great George Street, Westminster, London, S.W.1, "The Work of the Nautical Almanac Office," D. H. Sadler, 5.45 p.m.

### SOCIETY OF CHEMICAL INDUSTRY

*Wed., Oct.* 9.—CORROSION GROUP: 14, Belgrave Square, London, S.W.1, "The Corrosion Resistance of Titanium," J. B. Cotton and H. Bradley, 6.30 p.m.

### SOCIETY OF ENGINEERS

*Mon., Oct.* 7.—ORDINARY MEETING: Geological Society, Burlington House, Piccadilly, London, W.1, "War Damage Reconstruction Work on Premises of Messrs. Peter Robinson, Ltd., I. C. Cocking, 5.30 p.m.

### SOCIETY FOR WATER TREATMENT AND EXAMINATION

*To-day, Oct.* 4.—Palace Hotel, Southend-on-Sea, Autumn Meeting.

### WOMEN'S ENGINEERING SOCIETY

*To-day, Oct.* 4.—LONDON BRANCH: Central Electricity Authority's Headquarters, Winsley Street, near Oxford Circus, London, W.1, "Careers for Girls in Engineering," Miss M. M. Nobbs, Mrs. D. Fairweather, Miss G. M. Mettam and Mrs. D. G. Scrivener, 6.45 p.m.